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Table of Contents

Training and the Game

Humanities

PERFORMANCE FACTORS IN WOMEN'S TEAM HANDBALL

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Summary
The purpose of this article was to review a series of studies (n=33) on physical characteristics, physiological attributes, physical attributes, throwing velocity and on-court performances of women's team handball players.

Keywords
Anthropometric characteristics, sports performance, throwing velocity, on-court performance

Introduction
Since its introduction in 1972 at the Summer Olympic Games (18), handball has become more popular as a sport in general. Handball is a very strenuous body-contact sport characterized by highly developed motor skills such as speed, explosive power, endurance, and strength (40). The athlete's performance in high-level women's handball depends directly on diverse physiological attributes. In order to reach maximum player performance in handball, it is essential to use knowledge from various sports-related domains, including exercise physiology and sports medicine (50).

The importance of women's handball in research literature has grown exponentially, with the most relevant articles published over the last five years (2, 13, 16, 17, 18, 20, 24, 26, 29, 40, 45, 46, 47, 48). We also have included some of our own unpublished data with a special focus on on-court movement characteristics. Nevertheless, evidence-based knowledge for trainers and sport scientists regarding women's elite team handball is limited, although necessary for further developing player's skills and handball in general. Therefore, the first objective of this review is to summarize the scientific knowledge in women's handball.

Thus, the current article has two aims: (a) to review a series of studies (n=33) on physical characteristics, physiological attributes, throwing velocity and accuracy, and on-court performances of women's handball players including: amateur players, professional players, and national team players and (b) to summarize the status of scientific knowledge in women handball including fields with a clear need for further studies in order to stimulate more

Methods
A review of the literature on physical and physiological aspects of women handball players was conducted. The reviewed articles were selected from an extensive search of the literature in English, including major computerized databases (PubMed, Medline and SPORT Discus) and library archive search tools. Various combinations of keywords were used, including: handball, team, women's, women, physiological, physical and player. Data from unpublished studies conducted by the authors were also included. Ultimately, thirty three articles were included in this review.

Results and discussion

In order to plan, design and implement successful short-term and long-term training programs for women handball players, it is essential to gather information about the physical characteristics and physiological attributes of the players.

Physical characteristics

It is well known that body size affects physical performance. A taller person would perform better in activities with a significant strength component. Athletes specialized in throwing events are taller, heavier and more muscularly built than non-throwers. Body size has a strong positive effect on throwing performance and isometric strength (43, 47). A summary of the physical characteristics of women's handball players across the reviewed studies is presented in *Table 1* (see Annex).

In order to succeed in specific sport activities, it is often necessary to have certain physical characteristics. For ball games in which it is essential to use one's hands, hand morphology and functional properties may play a key role for performance (2). It is believed that a stable ball grip allows the athlete to accelerate the ball to a maximum during the entire throwing movement (42).

In conclusion, players with a higher skill level are taller and have a higher fat-free mass (4, 16, 34, 35, 43, 47). Players with larger hand can grab the ball more tightly and this fact probably gives the player the confidence to accelerate the ball as much as possible throughout the whole movement pathway (2, 42, 47).

Physiological attributes

Handball is a team sport of an intermittent nature which requires considerable physiological attributes such as the aerobic profile. A high aerobic capacity appears to be important in order to maintain a high level of performance over the 60 min of playing time.

Aerobic profile

Eleven studies examined the aerobic capacity of women's handball players. Seven of the studies mentioned collected maximal oxygen consumption (VO_{2max}) data of players from different competition levels, while the others focused on run velocities corresponding to certain blood lactate concentrations (*Table 2* – see Annex).

Physical attributes

Modern style handball involves intense physical contact throughout the entire match in defense, counterattack and positional attack. Only players with high physical capacities can effectively satisfy such requirements (20). Thus, physical attributes such as power and strength, running speed, and throwing velocity are important factors for success in competitive women's handball. Therefore, these capacities are now discussed for women handball players.

Power and strength

Muscle strength is an important factor in handball performance (23). Most researchers agree that higher maximal power and strength may be associated with an advantage in blocking, hitting, pushing (16) and ball throwing velocity (3, 10, 22, 31).

ANNEX

Table 1. A summary of studies on physical characteristics of female team-handball players

Study	n	Play position/ participants	Age (years)	Training (years)	Height (cm)	Body mass (kg)	BMI	Percent fat (%)	Fat-free mass (kg)
Bayios&Bergeles (4)	101 121	Greek first NL Greek second NL	21.5 ± 4.6	8.8 ± 4.2	165.9 ± 6.3	62.1 ± 9.1	23.6 ± 2.7	25.9±3.3	48±6
Cizmek et al (5)	37	Elite Croatian P.	24.49±4.14		174.74±6.75	69.46±8.57	22.70±1.99	19.39±4.50	
Filaire & Lac (9)	14	French National level	24.1 ± 2.6		167.8 ± 5.3	61.0 ± 7.5			
Granados et al.(16)	16	Elite Spanish P.	23.8 ± 4	12.7 ± 5	175.4 ± 8	69.8 ± 7	20.5 ± 5		
	15	Amateur players	21.4 ± 3	10.4 ± 3	165.8 ± 4	64.6 ± 5	23.3 ± 3		
García et al (11)	11	Spain NT	28.07±4.41		174.10±6.01	68.55±7.88	22.58±1.9		
	16	Spain B NT	22.09±3.33		176.55±7.93	71.13±7.77	23.45±1.9		
	14	Spain Junior NT	18.42±0.62		169.93±4.51	69.26±9.62	23.95±2.9		
	18	Spain Young NT	16.74±0.59		168.67±16.50	70.36±12.13	25.73±9.7		
Garcin et al. (12)	11	French League	19 ± 0.8		168.4 ± 2.5	62.0 ± 5.2			
Hasan et al. (18)	11	Goalkeeper/Asian NT	23 ± 2.1		175.8 ± 0.01	68.3 ± 6.3	23.3 ± 2.8	23.3±2.8	
	24	Back / Asian NT	22 ± 1.4		169.3 ± 0.02	62.2 ± 2.1	19.4 ± 2.4	19.4±2.4	
	13	Center/Asian NT	23 ± 4		171.8 ± 0.04	66.9 ± 4.5	20.6 ± 3		
	12	Wings/ Asian N.T	21± 2		170.0 ± 0.08	63.5 ± 7.9	21.8 ± 2.9	21.8±2.9	
Jadach et al. (20)	15	Poland NT	26.4		173.3	68.3	22.1		
Jensen et al., (21)	8	Norway NT	20.4±2.3		174.3±6.7	71.6±5.7			
Leyk et al., (24)	15	Elite Germany	22.6±4.7		172.0±0.5	68.7±4.8	23.3±2.3	25.6±5.5	51.0±2.7
Lian, et al. (25)	52	Norway NT	22.8 ± 4.3	14.9±4.2	172 ± 6	68.8 ± 8.4			
Manchado et al.(29)	16	Germany NT	26.6±3.8		176.0±7.4	70.4±6.8			
Michalsik (33)	24	Wings/Denmark NL Pivot/Denmark NL Back/Denmark NL	25.7±3.3		169.3 177.7 177.0	63.5 72.5 70.6			
Milanese et al. (34)	26	Elite Italian P.	26.4±5.77		169.2±6.04	67.0±7.91	23.4±5.33	23.3±5.33	
	17	Amateur Italian P.	17.3±2.25		166.0±5.10	64.4±10.47	23.3±4.01	28.6±4.01	
Ronglan et al. (39)	7	National Norway	23.7 ± 2.1		179.0 ± 0.04	72.0 ± 6.3			
	8	Norway NT	23.1 ± 2.0		176.0 ± 0.05	71.2 ± 1.8			
Saeterbakken et al. (40)	24	Young Norway	16.6±3.1	8.1±1.4	1.69±7.3	63.0±5.9			
Van den Tillaar&Ettema (43)	20	Norway NL	22.2 ±2.6	13.2±2.7	170.9±6.2	69.0±8.7		28.4±3.6	
Vargas et al. (45)	20	National Brazil	18,0±2,1		170.23±6,21	64.9±7.1			
Vila et al. (46)	130	Elite Spainish P.	25.74 ± 4.84	14.92 ± 4.88	171.31 ± 7.42	67.55 ± 8.06	22.97 ± 1.86		
Zapartadis et al.(48)	181	Young Greece	14.12±1.09	3.41±1.67	163±7.0	57.46±7.94	21.49±2.35		
Zapartidis et al.(49)	16	Greek first NL	20.5±1.9	8.5±1.8	168±0.08	62.38±6.19			

NT.:National Team NL: National League P: Players TBP: to be published

Table 2. A summary of studies on aerobic profile of female team-handball players

Study	Participants	Method	Age (years)	Height (cm)	Body mass (kg)	VO_{2max} *ml/kg/min*	V_4 V_3 (m/s)	HR *b/m*
Granados et al. (16, 17)	Amateur N= 15 Spain	Submaximal Progressive	21.4±3	165.8±4	64.6±5		2.5±0.3 (V3)	
	Elite N=16	running test	23.1±4	175.4±8	69.8±7		3.06±0.2 (V3)	
Granados et al. (15)	Spain Elite Team N=14	Submaximal Progressive running test	27.0±3	175.7	70.3		3.24 (V3)	
Jadach (20)	Poland National Team	Treadmill	26.4	173.3	68.3	48.75±3.38		190.0±7.8 HRmax
Jensen et al., (21)	Norway National Team N=8	Treadmill				51.3 ± 2.3		
Manchado (28)	Spain National Team N=16	Treadmill				47.2 ± 4.5		
Manchado *et al*.(29)	Germany National Team N=14	Mader test (V_4) HR during matches	26.6±3.8	176.0±7.4	70.4±6.8		3.34±0,31 (V_4)	161,1± 3.3 HRwork 86% HRmáx
Manchado, et al.(30)	Norway National Team N=14	Treadmill	25.9 ± 2.2	175.9 ± 6.4	67.5 ± 6.4	55.5 ± 3.9	3.73±0.19 (V_4)	194.9 ± 4.3 HRmax
Manchado, et al.(30)	Germany 1st Division	Treadmill	24.5 ± 3.4	174.4 ± 6.5	68.2 ± 3.5	50.2 ± 4.3	3.47±0,23 (V_4)	194.8 ± 6.3 HRmax
Michalsik (33)	Denmark Elite players N=24	Treadmill	27.7±3.3	174.9±5.7	70.3±7.4	47.5		
Nogueira et al. (36)	Brazil National Team N=17	Treadmill	25.6±3.7	173.6±5.4	66.4±7.7	45.3±5.4		
Rodahl et al. (37)	Norway National League	Treadmill	22.1 ± 4.5	172.0± 6.4	68.2± 7.4	47.7 ± 4.1		
Vargas et al.(45)	Brazil 1st Division	Cicle ergometer	18,0±2,1	170,23±6,21	64,9±7,1	45,3±3,0		

Table 3. A summary of studies on throwing velocity and accuracy in female team-handball players

Study	Participants and methodology	Treatment	Characteristics of throw Velocity ($m.s^{-1}$)
Granados et al. (16)	Elite players (n=16) First Spanish League Amateur players (n=15) Photocell gates	Descriptive study	Standing throw: Elite players: 19.5±1.1 Amateur players: 17.4±1.3 Three steps throw: Elite players: 21.1±1.3 Amateur players: 18.8±1.2 11% difference between elite and amateur players 8-7% difference between standing and three steps throw, respectively.
Granados et al. (17)	Elite players (n=16) First Spanish league Photocell gates	Follow-up during a season. Testing at beginning of the preparation phase (T1), beginning and end of first competition phase (T2 and T3, respectively), and end of second competition phase (T4)	Standing throw: T1: 19.0±0.9, T2: 19.5±1.2, T3: 20.2±1.7, T4: 20.5±1.3 Three steps throw: T1: 20.0±1.3, T2: 21.1±1.3, T3: 21.5±1.4, T4: 21.8±1.4 Significant increases (p<0.01) for both types of throwing at T4, T3 and T2 compared with T1
Hoff and Almasbakk, (19)	Norway 2nd Division (n=16) Aged 17 to 26 years Photogrametry	9 weeks of training, 3 sessions per week Group 1: Maximum strength bench-press training + normal handball training Group 2: Only normal handball training	Standing throw: Group 1: pre: 19.8±2.34, post: 23.3±1.79, improvement: 3.5±0.88 (18%) Group 2: pre: 18.5±1.29, post: 21.1±0.97, improvement: 2.7±1.64 (15%) Three steps throw: Group 1: pre: 23.1±2.01, post: 27.0±2.33, improvement: 3.9±1.12 (17%) Group 2: pre: 22.6±1.78, post: 24.6±1.47, improvement: 2.0±1.53(9%)
Van Muijen et al., (44)	1-2 National Level (n=45)	8 weeks of training (60 throws per week) Control group (CG): normal handball training Heavy training group (HT): 500 gr. balls Light training group (LT): 300 gr. balls	Standing throw: No changes in CG and HT groups. LT group: pre: 16.90±1.28, post 17.26±1.27, improvement: 2%
Vila et al., (46)	Elite players (n=130) First Spanish league Radar gun	Descriptive study. Four types of throws tested: 7m 9m standing just behind the line 9m with three step running 9m with an upward jump	See sub-table below
Zapartidis et al. (49)	Greece 1st Division (n=16) Age: 20.5 ± 1.9 Radar Gun	Descriptive study. Simulated game activities for 60 min (2 halves of 30 min). Ball velocity and accuracy tested every 10 min. 3 shots on the spot from 7 m distance.	See sub-table below

Vila et al., (46):

Position	n	7m	9m standing	9m three steps	9m jump
Center	16	20.80±1.42	21.11±1.48	23.11±1.10	22.47±1.59
Back	36	20.93±1.68	21.05±1.57	22.96±1.88	22.33±1.59
Wing	41	20.30±1.64	20.45±1.55	22.10±1.7	21.78±1.42
Pivot	18	21.02±1.84	20.78±1.87	22.53±1.77	22.00±2.00
Goalkeeper	19	19.52±0.93	20.23±1.02	21.75±1.68	20.79±1.72
Total	130	20.58±1.63	20.74±1.55	22.52±1.74	21.98±1.62

Zapartidis et al. (49):

Measurement	Ball velocity ($m.s^{-1}$)	Accuracy (cm)
A1	16.52±1.64	28.27±7.79
A2	16.92±1.52	27.55±7.73
A3	16.56±1.64	31.64±8.66
B1	16.64±1.41	29.18±7.06
B2	16.81±1.57	29.6±9.22
B3	16.6±1.59	33.14±7.33

Differences in power and strength have been shown to be relatively marked between elite and amateur players. These findings suggest that high absolute values of maximal strength and muscle power are required for successful performance in elite women's handball.

Running speed

Running speed is an important prerequisite factor in competitive handball (10).
The power of the lower extremities and the maximum running speed are significantly correlated with ball throwing velocity (16, 31, 49). This is supported by the fact that the main factor affecting ball velocity is the effective energy transition from the ground to the lower extremities and through the kinematic chain to the throwing upper limb (3, 22).

Throwing velocity and accuracy

Throwing ability is one of the most vital skills in handball and a very important aspect for success (16). For a throw to be effective, the highest velocity at ball release in combination with aiming accuracy is required (19). The faster the ball is thrown at the goal, the less time the defenders and the goalkeeper have to save the shot.

A summary of studies examining throwing velocity and accuracy in women's handball players is presented in Table 3 (see Annex). These data should be interpreted with care, because there are very few studies, the methodologies used are different (radar gun, photogrammetry, photocell gates) and sample levels vary as well.

On-court performances

Time-motion analysis is an effective method of quantifying the demands of team handball and provides a conceptual framework for the specific physical preparation of players. An effective and efficient training regime should be based on a time-motion analysis and should include intermittent drills in which handball players have to perform different motions with different paths/movements at the highest intensity possible, followed by lower intensity periods, all according to the specific demands of each playing position.

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THE COMPARISON OF CUMULATIVE INDICATORS OF TEAM PLAYING PERFORMANCE BETWEEN GENDERS: OLYMPIC GAMES HANDBALL TOURNAMENTS 2008 AND 2012

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Summary
By means of comparison, we are using the cumulative statistics data obtained through observation of all the matches of the Olympic handball tournaments 2008 and 2012 in both gender categories. The indicators of team playing performance are shooting and goalkeeping efficiency from different positions (pivot, wing, back) and situations (break through, fast break, seven meter throw) and total efficiency, percentage of goals from different positions and situations, average of score results, average of attacks and average of technical errors pro team in one match. All indicators are further classified by each competition based on the final teams ranking (three performance groups) and according to gender.

Keywords
Handball, Cumulative Indicators, Team Playing Performance, Men, Women

Introduction

It is without doubt that differences, which are caused by biological (genetic) and social sources exist between genders. We have enough documents to present these differences, also through the examples of handball players from various anthropometrical, physiological and psychological aspects. In the handball "Rules of the Games" there are only two exceptions concerning the size and weight of the ball for female categories compared to male categories. Both evoke the question of how it is for both genders based on selected indicators of team playing performance (hereinafter TPP). Former studies of the author indicate that historically the differences between genders in reachable indicators of TPP are significantly smaller as fifty years ago. The reason is evidently the aligning of conditions of training and competition.

Professional question and premise

From the statement above we formulate the subsequent question: Do distinctions exist among the selected cumulative indicators of TPP in men´s and women´s teams? On the basis of a number of previous observations and assessments, we assume that the differences among the selected cumulative indicators of TPP in men's and women's teams do not have factual significant evidence.

Subject

We summarized selected data from all the matches of both men and women at the Olympic Games (OG) handball tournaments 2008 and 2012. It was totally 160 matches (42 men´s, plus 42 women´s in Beijing 2008 and 38, plus 38 in London 2012). The reasons of choosing OG matches are the following:
- The data harvesting (see further) was achieved through a unified method.
- Both male and female teams are playing during the same period, in identical sport halls and accommodated in the same environment.
- For the first time in history, the men's and women's handball teams competed 12 teams each and after the completion of the same kind of qualification systems.
- Compared to World Championships or European Championships, all teams had much more time for preparation.

- The Olympics are the only tournament with always one rest day between two matches allowing better physical and psychological recovery of the players.
- The atmosphere during the Olympic tournaments highly motivates all participants involved.

The data harvesting

The data on particular indicators of TPP were obtained through a trained team of observers, which followed all matches on both Olympic tournaments in Handball (2008 and 2012). The observed facts were electronically recorded by Swiss Timing, using instruments from the concern Omega. Swiss Timing has a long term partnership with both the International Handball Federation (IHF), as well as the European Handball Federation (EHF) on the observation of selected indicators of playing performance, not only during the Olympic Games and the Olympics Qualifications, but also during WChs and EChs.

Methodical remarks

We understand the term **cumulative indicators** as aggregative, absolute and relative degrees of TPP from all matches of the presented teams, performance groups of teams or all teams respectively at the OG tournaments. The concentration on the selection of cumulative indicators of TPP accentuates the effort of the monitoring of the more general trends and relationships. Therefore, we have neither resigned on casual evaluation of procurable indicators of TPP in singular matches (especially in relation to concrete opponent occurs to noticeable oscillations in values of indicators) nor on assessment of all procurable indicators of playing performance (groups and individual players). We chose as a measure of **factual** (pragmatic) **significant evidence** such differences among indicators, which can influence the final result of the match. It means that these differences can potentially affect the achievement of one or more goals. It is approximately the difference of two attempts of shooting, alternatively of two attacks or two lost balls by one team during one match. In the cases of percentage efficiency or percentage difference it is possible to estimate as measure of factual significant evidence approximately around 3.5 and 4 percent. In accordance with the final ranking, we separated the men’s and women’s teams into three performance groups: teams ranked 1 to 4, 5 to 8 and 9 to 12. The main working methods (besides of simple statistical data processing) are descriptive and comparative analysis of obtained indicators.

Results and discussion

Analyzing the efficiency of shots - **Table 1 - it** is possible to underline the following observations:

- **Total** efficiency of shots is very similar in both genders and according to our factual evidence, not significant.
- The efficiency from the **pivot** position is similar with small increasing tendencies.
- The efficiency from the **wing** position was on OG 2008 significantly lower for women than for men. But four years later, both genders were coming on the same level. This can possibly be the result of better physical preparation of women. First of all, better jumping skills were observed, which facilitate the opening of the shooting angle and increase the time for shot during the jump.
- The significance of differences in the efficiency between men and women in the shots from the **back** court player’s position is on the edge. Nevertheless, the constitution (longer hands) and physiological (explosive strength) advantages give male players a better possibility to throw the ball faster from longer distances.
- The efficiency of shots in **break through** situations increased for women between 2008 and 2012 on a similar level as for men.

- Similar development is possible to notice concerning the efficiency in a **fast break** situation. The increase for women during the four-year period is remarkable.
- Significant difference of efficiency beneficially for the men is in **7-meter** situation.

Table 1: Efficiency of Shots

C	Rank Group	Gm	**Goals** / Shots / **Efficiency in %**													
			Pivot	**%**	**Wing**	**%**	**Back**	**%**	**BT**	**%**	**FB**	**%**	**7m**	**%**	**Total**	**%**
M 2008	**1-4**	32/2	**220** /300	**73,3**	**133** /219	**60,7**	**212** /574	**36,9**	**93** /125	**74,4**	**187** /255	**73,3**	**89** /115	**77,4**	**934** /1588	**58,8**
	5-8	32/2	**163** /265	**63,9**	**100** /169	**59,2**	**286** /711	**40,2**	**68** /98	**69,4**	**174** /246	**70,7**	**83** /113	**73,5**	**874** /1602	**54,6**
	9-12	20/2	**110** /174	**63,2**	**47** /93	**50,5**	**170** /434	**39,2**	**43** /65	**66,2**	**83** /126	**65,9**	**33** /49	**67,3**	**486** /941	**51,6**
	Total	**42**	**493** /739	**67,6**	**280** /481	**58,2**	**668** /1719	**38,9**	**204** /288	**70,8**	**444** /627	**70,8**	**205** /277	**74,0**	**2294** /4131	**55,5**
M 2012	**1-4**	*32/2*	**174** /246	**70,7**	**140** /242	**57,9**	**258** /612	**42,2**	**88** /116	**75,9**	**148** /179	**82,7**	**79** /102	**77,5**	**887** /1497	**59,3**
	5-8	*24/2*	**128** /181	**70,7**	**112** /196	**57,1**	**192** /468	**41,0**	**59** / 81	**72,8**	**101** /133	**75,9**	**60** /76	**78,9**	**652** /1135	**57,4**
	9-12	*20/2*	**88** /129	**68,2**	**59** /124	**47,6**	**148** / 446	**33,2**	**48** / 81	**59,3**	**60** /93	**64,5**	**41** /63	**65,1**	**444** /936	**47,4**
	Total	**38**	**390** /556	**70,1**	**311** /562	**55,3**	**598** /1526	**39,2**	**195** /278	**70,1**	**309** /405	**76,3**	**180** /241	**74,7**	**1983** /3568	**55,6**
W 2008	**1-4**	*32/2*	**164** /239	**68,6**	**116** /215	**54,0**	**228** /587	**38,8**	**114** /158	**71,2**	**205** /298	**68,8**	**108** /158	**68,4**	**935** /1655	**56,5**
	5-8	*32/2*	**150** /212	**70,8**	**103** /206	**50,0**	**223** /647	**34,5**	**97** /154	**63,0**	**173** /245	**70,6**	**105** /145	**72,4**	**851** /1609	**52,9**
	9-12	*20/2*	**79** /125	**63,2**	**63** /137	**46,0**	**124** /397	**31,2**	**64** / 96	**66,7**	**81** /136	**59,6**	**54** /79	**68,4**	**465** / 970	**47,9**
	Total	**42**	**393** /576	**68,2**	**282** /558	**50,5**	**575** /1631	**35,3**	**275** /408	**67,4**	**459**/679	**67,6**	**267**/382	**69,9**	**2251** /4234	**53,2**
W 2012	**1-4**	*32/2*	**162** /237	**68,4**	**130** /216	**60,2**	**216** /582	**37,1**	**111** /156	**71,2**	**102** /146	**69,9**	**100** /147	**68,0**	**821** /1484	**55,3**
	5-8	*24/2*	**110** /149	**73,8**	**87** /164	**53,0**	**174** /457	**38,1**	**86** /110	**78,2**	**127** /151	**84,1**	**60** /80	**75,0**	**644** /1111	**58,8**
	9-12	*20/2*	**77** /109	**70,6**	**72** /141	**51,1**	**133** /417	**31,9**	**48** /76	**63,2**	**56** /79	**70,9**	**58** /81	**71,6**	**444** /903	**49,2**
	Total	**38**	**349** /495	**71,0**	**289** /521	**55,5**	**523** /1456	**35,9**	**245** /342	**71,6**	**285** /376	**75,8**	**218** /308	**70,8**	**1909** /3498	**54,6**

In **Table 2,** we present the percentage of goals from different positions and situations. It is possible to state that:

- The percentage of goals from the **pivot** position was significantly higher for men in 2008, but in 2012 the gender values come relatively close together.
- From the **wing** position, the percentage of goals demonstrated a similar value and developing tendency (small increase).
- The percentage of goals from the **back** positions is higher for men but on the limit of significance only in 2008.
- Converse state (advantageous for women) is visible in the percentage of goals in **breakthrough** situations, but the differences are not significant. Because of the disadvantage of shots from longer distances, women use these individual actions more often.
- In the **fast break** situation, values are similar for both genders, with an evident tendency of decrease. The reason is probably the trend of accenting the defense.
- In a **7-meter** situation a similar state as in breakthrough is visible (from same reasons).

Table 2: Percentage of Goals from Different Positions and Situations

C	Rank Group	Gm	Total Goals / **Proportional Percentage**													
			Pivot	**%**	**Wing**	**%**	**Back**	**%**	**BT**	**%**	**FB**	**%**	**7m**	**%**	**Total**	**%**
M 2008	**1-4**	32/2	220	**23,6**	133	**14,2**	212	**22,7**	89	**9,5**	187	**20,0**	93	**10,0**	934	**100**
	5-8	32/2	163	**18,7**	100	**11,4**	286	**32,7**	83	**9,5**	174	**19,9**	68	**7,8**	874	**100**
	9-12	20/2	110	**22,6**	47	**9,7**	170	**35,0**	33	**6,8**	83	**17,1**	43	**8,8**	486	**100**
	Total	**42**	493	**21,5**	280	**12,2**	668	**29,1**	205	**8,9**	444	**19,4**	204	**8,9**	2294	**100**
M 2012	**1-4**	*32/2*	174	**19,6**	140	**15,8**	258	**29,1**	88	**9,9**	148	**16,7**	79	**8,9**	887	**100**
	5-8	*24/2*	128	**19,6**	112	**17,2**	192	**29,5**	59	**9,0**	101	**15,5**	60	**9,2**	652	**100**
	9-12	*20/2*	88	**19,8**	59	**13,3**	148	**33,4**	48	**10,8**	60	**13,5**	41	**9,2**	444	**100**
	Total	**38**	390	**19,7**	311	**15,7**	598	**30,1**	195	**9,8**	309	**15,6**	180	**9,1**	1983	**100**
W 2008	**1-4**	*32/2*	164	**17,5**	116	**12,4**	228	**24,4**	108	**11,6**	205	**21,9**	114	**12,2**	935	**100**
	5-8	*32/2*	150	**17,6**	103	**12,1**	223	**26,2**	105	**12,3**	173	**20,4**	97	**11,4**	851	**100**
	9-12	*20/2*	79	**17,0**	63	**13,5**	124	**26,7**	54	**11,6**	81	**17,4**	64	**13,8**	465	**100**
	Total	**42**	393	**17,5**	282	**12,5**	575	**25,5**	267	**11,9**	459	**20,4**	275	**12,2**	2251	**100**
W 2012	**1-4**	*32/2*	162	**19,8**	130	**15,8**	216	**26,3**	111	**13,5**	102	**12,4**	100	**12,2**	821	**100**
	5-8	*24/2*	110	**17,1**	87	**13,5**	174	**27,0**	86	**13,4**	127	**19,7**	60	**9,3**	644	**100**
	9-12	*20/2*	77	**17,4**	72	**16,2**	133	**30,0**	48	**10,8**	56	**12,6**	58	**13,0**	444	**100**
	Total	**38**	349	**18,4**	289	**15,1**	523	**27,4**	245	**12,8**	285	**14,9**	218	**11,4**	1909	**100**

Table 3 presents the goalkeepers' efficiency, which gives a de facto converse picture as shooting efficiency.

- **Total** efficiency of goalkeeping is very similar for both genders and according to our factual evidence not significant.
- Goalkeeping efficiency against shots from the **pivot** position presents non-significant differences between the two genders and small decreasing tendency.
- The most significant change (decrease from 42.0 % to 31.8 %) can be detected in women concerning the goalkeeping efficiency against the shots from the **wing** position. In 2008, female goalkeepers were, in this aspect significantly, better than male goalkeepers and, but in 2012 it was contrariwise.
- Concerning the efficiency against the shots from the **back** position, the values are relatively balanced, with a small advantage for female goalkeepers.
- In a **break through** situation, both genders are nearly at identical state.
- In the situation of a **fast break,** a decreasing percentage tendency in women is significant.
- In the execution of a **7-meter** throw female goalkeepers are more successful; in 2012 the supremacy to the male gender was significant.

Table 3: Goalkeeping Efficiency

C	Rank Group	Gm	**Goals** / Shots / **Efficiency in %**													
			Pivot	**%**	**Wing**	**%**	**Back**	**%**	**BT**	**%**	**FB**	**%**	**7m**	**%**	**Total**	**%**
M 2008	**1-4**	32/2	77/278	**27,7**	40/127	**31,5**	225/487	**46,2**	18/ 94	**19,1**	39/177	**22,0**	19/107	**17,8**	**418 / 1270**	**32,9**
	5-8	32/2	67/246	**27,2**	62/177	**35,0**	219/476	**46,0**	30/103	**29,1**	42/207	**20,3**	20/ 94	**21,3**	**440 / 1303**	**33,8**
	9-12	20/2	47/160	**29,4**	46/124	**37,1**	108/257	**42,0**	19/ 74	**25,6**	42/183	**23,0**	11/54	**20,4**	**273 / 852**	**32,0**
	Total	**42**	191/684	**27,9**	148/428	**34,6**	552/1220	**45,2**	67/271	**24,7**	123/567	**21,7**	50/255	**19,6**	**1131 / 3425**	**33,0**
M 2012	**1-4**	*32/2*	44/184	**23,9**	66/200	**33,0**	251/502	**50,0**	18/85	**21,2**	25/125	**20,0**	18/90	**20,0**	**422 / 1186**	**35,6**
	5-8	*24/2*	46/164	**28,0**	50/131	**38,2**	156/356	**43,8**	24/84	**28,6**	26/127	**20,5**	19/77	**24,7**	**321 / 939**	**34,2**
	9-12	*20/2*	36/171	**21,1**	61/157	**38,9**	91/238	**38,2**	24/92	**26,1**	20/128	**15,6**	6/56	**10,7**	**238 / 842**	**28,3**

	Total	**38**	126/519	**24,3**	177/488	**36,3**	498/1096	**45,4**	66/261	**25,3**	71/380	**18,7**	43/223	**19,3**	**981 / 2967**	**33,1**
W 2008	**1-4**	*32/2*	50/206	**24,3**	95/210	**45,2**	217/421	**51,5**	25/119	**21,0**	48/218	**22,0**	31/121	**25,6**	**466 / 1295**	**36,0**
	5-8	*32/2*	51/215	**23,7**	77/194	**39,6**	189/402	**47,0**	37/140	**26,4**	55/223	**24,7**	28/130	**21,5**	**437 / 1304**	**33,5**
	9-12	*20/2*	35/108	**32,4**	32/ 82	**39,0**	102/260	**39,2**	26/104	**25,0**	35/156	**22,4**	13/ 88	**14,8**	**243 / 798**	**30,5**
	Total	**42**	136/529	**25,7**	204/486	**42,0**	508/1083	**46,9**	88/363	**24,2**	138/597	**23,1**	72/339	**21,2**	**1146 / 3397**	**33,7**
W 2012	**1-4**	*32/2*	50/188	**26,6**	63/164	**38,4**	219/465	**47,1**	31/134	**23,1**	25/126	**19,8**	33/135	**24,4**	421 / 1212	**34,7**
	5-8	*24/2*	29/126	**23,0**	44/149	**29,5**	164/310	**52,9**	24/92	**26,1**	17/102	**16,7**	28/85	**32,9**	306 / 864	**35,4**
	9-12	*20/2*	25/139	**18,0**	28/111	**25,2**	101/232	**43,5**	25/99	**25,3**	13/112	**11,6**	9/68	**13,2**	201 / 761	**26,4**
	Total	**38**	104/453	**23,0**	135/424	**31,8**	484/1007	**48,1**	80/325	**24,6**	55/340	**16,2**	70/288	**24,3**	928 / 2837	**32,7**

Table 4 contains data about cumulative statistics of goal scoring, attacks, technical errors and efficiency. The following is remarkable:

- The average **goals score** significantly decreased for both genders by the comparison of 2008 and 2012 OG tournaments. It corresponds to the general trend of the last years to strengthen defense activities.
- The average number of **attacks** pro singular team in one match pointed out significant differences between men and women. In both genders there is also a significantly decreasing tendency (see the trends to strengthen defense activities).
- Concerning technical **errors,** significant differences can be observed between the two genders. Here, it is also necessary to mention that in all four competitions the last performance groups (9-12) were significantly worse than groups 1-4 and 5-8.
- The higher number of technical errors by female teams in comparison to men is also probably the reason for the higher number of attacks. It is simultaneously the explication way the shooting and goalkeeping average efficiency are on a very similar level for both genders.

Table 4: Cumulative Statistics of Scores, Attacks, Technical Errors and Efficiencies

C	Rank Group	Gm	Total Score	Average Result	Diff.	Total Att.	Aver. Att.	Total TE	Aver. TE	Att. Eff	Shoot. Eff	Keep. Eff
M 2008	**1-4**	32/2	938 : 852	**29,2 : 26,6**	+ 2,6	1812	**56,6**	386	**12,1**	**51,5**	**58,8**	**32,9**
	5-8	32/2	874 : 863	**27,3 : 27,0**	+ 0,3	1777	**55,5**	391	**12,2**	**49,2**	**54,6**	**33,8**
	9-12	20/2	486 : 579	**24,3 : 29,0**	- 4,7	1129	**56,5**	306	**15,3**	**43,0**	**51,6**	**32,0**
	Total	**42**	2294 : 2294	**27,3 : 27,3**		4718	**56,2**	1083	**12,9**	**48,6**	**55,5**	**33,0**
M 2012	**1-4**	*32/2*	887 : 764	**27,7 : 23,9**	+ 3,8	1722	**53,8**	356	**11,1**	**51,5**	**59,3**	**35,6**
	5-8	*24/2*	652 : 618	**27,2 : 25,8**	+ 1,4	1299	**54,1**	277	**11,5**	**50,2**	**57,4**	**34,2**
	9-12	*20/2*	444 : 601	**22,2 : 30,1**	- 7,9	1117	**55,9**	285	**14,3**	**39,7**	**47,4**	**28,4**
	Total	**38**	1983:1983	**26,1 : 26,1**		4138	**54,4**	918	**12,1**	**47,9**	**55,6**	**33,1**
W 2008	**1-4**	*32/2*	935 : 829	**29,2 : 25,9**	+ 3,3	2019	**63,1**	521	**16,3**	**46,3**	**56,5**	**36,0**
	5-8	*32/2*	851 : 867	**26,6 : 27,1**	- 0,5	2014	**62,9**	515	**16,1**	**42,3**	**52,9**	**33,5**
	9-12	*20/2*	465 : 555	**23,3 : 27,7**	- 4,4	1236	**61,8**	392	**19,6**	**37,6**	**47,9**	**30,5**
	Total	**42**	2251 : 2251	**26,8 : 26,8**		5269	**62,7**	1428	**17,0**	**42,7**	**53,2**	**33,7**
W 2012	**1-4**	*32/2*	821 : 791	**25,7 : 24,7**	+ 1,0	1863	**58,2**	486	**15,2**	**44,1**	**55,3**	**34,7**
	5-8	*24/2*	644 : 558	**26,8 : 23,3**	+ 3,5	1391	**58,0**	374	**15,6**	**46,3**	**58,8**	**35,4**
	9-12	*20/2*	444 : 560	**22,2 : 28,0**	- 5,8	1162	**58,1**	345	**17,3**	**38,2**	**49,2**	**26,4**
	Total	**38**	1909:1909	**25,1 : 25,1**		4416	**58,1**	1205	**15,9**	**43,2**	**54,6**	**32,7**

Conclusion

Regarding the above formulated professional question it can be answered with accordance to the analyses of reachable cumulative indicators of TPP and with the use of defined assessment criteria: The distinctions among the selected cumulative indicators of TPP between the men´s and women´s teams exist, but - with a few exceptions - were non-significant and often entirely negligible. The stated premise was therefore in the majority of observed indicators confirmed, and not possible to invalidate in this study. Soft trends in approaching the values between both genders and similar development trends are also noticeable, (but mostly not significant) by the majority of indicators.

Enclosures:
Legend to Abbreviations in Tables 1, 2 and 3
Legend to Abbreviations in Table 4
Table 1: Efficiency of Shots
Table 2: Percentage of Goals from Different Positions and Situations
Table 3: Goalkeeping Efficiency
Table 4: Cumulative Statistics of Scores, Attacks, Technical Errors and Efficiencies

Legend to Abbreviations in Tables 1, 2 and 3

- **C** = competition
- **M** = men
- **W** = women
- **1-4** = the teams ranking from first to fourth position
- **5-8** = the teams ranking from fifth to eight position
- **9-12** = the teams ranking from ninth to twelfth position
- **Gm** = number of matches
- **BT** = break through
- **FB** = fast break
- **7-m** = seven meter throw
- **%** = efficiency in percentage

Legend to Abbreviations in Table 4

- **Diff.** = difference
- **Aver.** = average
- **Att.** = attacks
- **TE** = technical errors (number of attacks terminated by mistake)
- **Att. Eff** = attacks efficiency in percentage
- **Shoot. Eff** = efficiency of shots in percentage
- **Keep. Eff** = goalkeeping efficiency in percentage

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WHY DO SO MANY KNEE INJURIES OCCUR DURING SIDECUTTING, AND WHY ARE FEMALE PLAYERS AT MORE RISK? A BRIEF REVIEW OF BIOMECHANICAL RISK FACTORS.

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Summary
This article present an overview on how acute knee injuries occur in handball. Anatomical, biomechanical and neuromuscular factors are presented and discussed based on the scientific information available today.

Keywords
Knee injury mechanisms; Biomechanical risk factors.; Female handball players.

Introduction

The highest incidence of non-contact anterior cruciate ligament (ACL) injury in ball sports is observed during team handball match play (Hewett et al, 1999; Olsen et al, 2004; Renström et al, 2008), making handball the most dangerous sport in terms of acute ACL-injury. In addition, it has been documented that young female team handball players are the most susceptible to sustain this type of injury (Lind et al, 2009; Reckling et al, 2003). This brief review highlights some of the risk factors that may explain why some handball players are more at risk than others.

Anatomy and physiological development

When investigating the aetiology of the ACL injury, and why young female players are at more risk than their male counterparts or older female colleagues, several parameters must be considered.

The reason why young female athletes are more at risk is not fully understood. Certainly, differences in natural physical development may be considered. Before puberty, boys and girls are very alike in physical performance parameters, but with the onset of the gender-specific hormone secretion during puberty the two gender start to develop differently. Boys increase muscle mass, and thus strength, more rapidly, while girls develop strength more slowly and also gradually increase the relative proportion of body fat. All other things equal, this reduces the girls' strength to body mass ratio relative to the boys, and this may influence the way girls cope with external loading of the lower extremities during physical tasks such as jumping, landing and side-cutting.

The anatomy of the knee joint explains the normal function of the ACL, and also which joint movements may put the ACL at risk of damage. Cadaver studies reveal that in the sagittal plane the anterior drawer of tibia in relation to femur will stretch the ACL, while in the frontal plane, knee abduction, or increasing the knee valgus, will also load the ACL. In the transverse plane, both internal and external rotation will increase the loading of the ACL. From the muscular insertions around the knee joint we will also learn, that in the sagittal plane the quadriceps muscle may pull the tibia forward and load the ACL, if no co-contraction from the hamstrings is present and the knee joint angle is between full extension and approximately 30 degrees flexion. In the frontal plane, the medial head of the quadriceps and in particular the medial hamstrings may resist the potentially dangerous knee abduction. In the transverse plane, both medial and lateral hamstrings may resist any rotation that could be of potential risk for the ACL.

Keeping the anatomy and physiology in mind, we also need to know why playing handball may cause this amount of serious injuries. In team handball, the highest frequency of ACL injuries is seen during non-contact side-cutting movements (Myklebust et al, 1998; Strand et al, 1990). The side-cutting manoeuvre in handball is usually very abrupt and explosive, with a very large angular change of direction, and this distinguishes the handball side-cut from other, more forward oriented, sports-specific movements like landing, drop jumping or side-cutting in, for example, soccer, which have been investigated in other studies.

Using 3-D motion analysis to investigate the biomechanics of the side-cutting manoeuvre

In order to understand why the handball side-cutting manoeuvre is so hazardous and why young female players are most at risk, biomechanical investigations of the movement must be performed. The use of kinematic analyses of the joint angles in all three planes of movement along with kinetic calculations of external forces acting around the joints (moments) will help us to understand, how the positioning and movements of the limbs and trunk during the landing and deceleration phase are related to the loading of the knee joint. This way, we may improve knowledge about correct technique and how to reduce the hazardous loadings of the knee. Furthermore, examination of the neuro-muscular activation patterns is necessary to describe how our muscles are activated to control the movement and resist the external forces trying to abnormally load the knee during this particular risk-full, but however important, movement in handball.

We learn from other studies on a variety of similar sports-specific movements have shown that the kinematics and kinetics around the knee and hip may influence the risk of ACL injury (Ford et al, 2006; Jacobs et al, 2007; Krosshaug et al, 2007; Olsen et al, 2004). Especially, high external knee valgus moments have been shown to be predictive of ACL injury (Hewett et al, 2005) and that the control of the hip joint may influence the magnitude of the knee valgus moment (McLean et al, 2005).

Only one older and two very recent studies have described the biomechanical characteristics of the handball side-cutting manoeuvre in female handball players (Simonsen et al, 2001; Bencke et al 2013; Kristianslund et al 2013) and the aim of these studies were to investigate the kinematics and kinetics of the hip and knee joint during side-cutting. Information from video-based case-studies on incidences of ACL-injuries during match-play indicates that the injury occurs very early, about 30-40 milliseconds, after ground contact (Krosshaug et al, 2007), and therefore focus was concentrated on the joint angular position at initial contact and the external moments during the first 100 ms after initial contact.

The studies produced similar results, showing that female players usually land with the knee in 20-25 degrees of flexion and in slight knee valgus, while the hip was around 20 degrees abducted but in neutral rotation (Bencke et al 2013; Kristianslund et al 2013). When observing the external moments of the joints, it appears that the knee is loaded with an early (approximately 30 ms after initial contact) peak external knee valgus moment, coinciding with a peak in the transverse plane moment attempting to externally rotate the knee. Around the hip joint external abduction moments and internally rotating moments are observed, temporally coinciding with the knee joint moments. This implicates, that if no internal muscular moments are present, the knee would become externally rotated and abducted, which are movements loading the ACL.

The study of Kristianslund et al (2013) concludes that an execution of the side-cutting manoeuvre with the centre of mass more above the foot while cutting and landing more on the toes will reduce the potentially hazardous knee valgus moment. The study of Bencke et al (2013) additionally points to importance of high force activation in the muscle groups resisting the coinciding moments around the hip and knee. From these biomechanical studies it seems important to activate especially the medial hamstrings, which may counteract the external moments potentially inducing knee valgus and knee external rotation, and around the hip, the external rotators may counteract the moment forcing the hip into internal rotation. To investigate this, studies on the neuro-muscular coordination are necessary.

Using electromyography to study neuro-muscular coordination during side-cutting

The importance of high activation of the medial hamstrings during initial contact was substantiated in a study on neuro-muscular coordination in adult female handball players during side-cutting (Zebis et al, 2009). In a study on 55 elite players, 5 players suffered an ACL injury within the subsequent 2 seasons after the testing. The injured players showed significantly lower activation of the medial hamstrings compared to the rest, indicating that high activation of the medial hamstrings is necessary to protect the knee joint during side-cutting. Differences in neuro-muscular activity patterns may also be a part of the explanation when trying to explain why female athletes are at more risk of sustaining an ACL injury than male athletes. Bencke & Zebis (2011) showed, that male handball players had higher levels of hamstring activation than female handball players during side-step cutting, which potentially enables a better knee joint stability for the male players during side-cutting.

Based on these data, it seems that activity of the medial hamstrings immediately before landing in a side-cutting manoeuvre is very important for the prevention of ACL-injuries.

Conclusions

Differences in physiological development may induce relatively higher physical challenges for the young female handball player compared to the male counterpart because of the lower strength to body mass ratio developed during puberty.

The biomechanical studies of the handball side-cutting manoeuvre have shown coinciding external moments loading the knee into valgus and outward rotation and simultaneously loading the hip into internal rotation and abduction. These movement-specific loading patterns emphasize the dependency on the medial hamstrings to counteract the external knee valgus moments and knee outward rotation moments, and the importance of hip outward rotators to counteract the external inward rotation moment. Furthermore, females were shown to have lower activation of hamstrings compared to men, and especially low activity of the medial hamstrings was evident in female players who later suffered an ACL injury.

For coaches and physical trainers these data implicates that focus on correction of technique into a less abnormal joint loading may be important, and in particular doing exercises that induces higher activation of the medial hamstrings during side-step cutting.

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EFFECT OF KNEE INJURY PREVENTION IN HANDBALL: WHICH EXERCISES SHOULD WE CHOOSE?

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Summary
With special focus on potential risk factors for knee injury, a detailed description of a validated ACL injury prevention program will be given along with the neuromuscular adaptation induced by this type of training in female team handball players. Further, a neuromuscular evaluation of specific exercises will be given. By the use of EMG, muscle activity during execution of balance/coordination and strength exercises can be assessed, and data on the neuromuscular stimuli when these exercises are implemented in the weekly training will be presented.

Keywords
ACL injury prevention, risk factors, neuromuscular adaptations, exercise evaluation, team handball, female

Introduction
In the prevention of ACL injuries it is essential to identify risk factors relating to this serious knee injury. A study by Hewett et al.(Hewett TE, et al., 2005) identified dynamic valgus of the knee as a predisposing factor for ACL injury in female athletes. Concordantly, low Semitendinosus electromyographic (EMG) activity during sidecutting – a movement associated with the incidence of non-contact ACL injury – in combination with high Vastus Lateralis (VL) activity may increase the risk for sustaining ACL injury (Zebis MK, et al., 2009). The balance between medial-lateral hamstring recruitment seems highly important for the control of dynamic valgus. Female athletes have a disproportionately greater EMG activity in their lateral hamstrings (Biceps Femoris) than male athletes when landing from a jump (Rozzi SL., et al., 1999). Increased lateral hamstring motor unit firing potentially leads to a more open medial joint space and thereby potentially contributes to increased dynamic valgus. Furthermore, Myer et al. (Myer GD., et al., 2005) found that female athletes demonstrated a reduced medial-to-lateral (VM-to-VL) quadriceps EMG ratio compared to male athletes; this factor could also contribute to ‘‘dynamic valgus’’ in high-risk manoeuvres. During sidecutting, medial hamstring muscle contraction therefore seems very important in compressing the medial knee joint compartment and thereby counteracting the risk of dynamic valgus.

In recent years, a huge step is taken towards prevention of serious sports injuries like anterior cruciate ligament (ACL) injuries. High quality studies have documented that specific prophylactic training can reduce the incidence of serious knee injuries in team handball [5, 6]. The validated training protocols involve balance, coordination, strength and plyometric exercises (Myklebust G., et al., 2003; Olsen OE, et al., 2005). However, few studies have evaluated how neuromuscular training – shown to reduce the incidence of ACL injuries – actually affects the neuromuscular system in female team handball players during high risk movements associated with ACL injury.

Neuromuscular adaptation to a validated ACL prevention program in female team handball
In our lab we investigated the effect of a neuromuscular training program originally developed at the Oslo Sports Trauma Research Centre (www.klokavskade.no) (Zebis MK., et al., 2008).We modified the program to include 6 levels, each consisting of 3 exercises. Each of the 6 levels had to be followed 2 times per week for 3 weeks before progressing to the next level. After

completing the program (18 weeks), the 6 levels were performed again with increasing difficulty of the exercises. The main focus of the exercises was to improve awareness and neuromuscular control of the hip, knee, and ankle muscles during standing, running, cutting, jumping, and landing tasks with simultaneous ball handling and included exercises on wobble board (disc diameter, 38 cm; Norpro, Notoddon, Norway, 2000) and balance mat (40 3 50 cm2; 7-cm-thick; Alusuisse Airex, Sins, Switzerland, 2000). The program was performed twice weekly, and each exercise session lasted 20 minutes. After careful supervision, the involved team physiotherapists and physical trainers were involved in the coaching of the neuromuscular training program. The principal examiner conducted successive follow-ups every second week. The main finding in the present study was that neuromuscular training induced a change in the pattern of neuromuscular activation of the hamstring muscles during sidecutting. The selective increase in semitendinosus activity in the prelanding phase and the initial landing phase in parallel with the unchanged neuromuscular activity of the quadriceps muscles may represent an important adaptation in response to neuromuscular training. During rapid movements like sidecutting, which involve substantial eccentric quadriceps forces it seems essential to have adequate neural preactivation of the hamstring muscles just before ground contact to protect the ACL. In accordance with our findings, a previous study found that the hamstrings are not activated maximally during rapid sidecutting, and it was speculated that increased coactivation of the hamstring muscles would result in a non-optimal execution of the sidecutting manoeuvre (Simonsen EB., et al., 2000). This latter notion was not confirmed by the present results because duration of the sidecutting (ground contact time) was not affected, despite increased neuromuscular activity in the semitendinosus muscle.

Specific exercise evaluation

In order to further optimize prophylactic training, an extensive exercise evaluation is needed based on an anatomical and biomechanical rationale. It is not well documented how specific exercises challenge the neuromuscular system in respect to the hamstring muscles. Thus, there is a strong need to gain knowledge about the muscle activity pattern during exercises used in both ACL prevention and rehabilitation interventions.

Common strength exercises for the leg muscles such as squats, leg presses and knee extensions show high levels of muscle activity in the quadriceps along with a preferential higher lateral compared with medial hamstring muscle coactivation (Andersen LL., et al., 2006). Focusing primarily on these exercises may predispose for knee injury. Thus, from a prophylactic perspective it is relevant to evaluate the medial Semitendinosus versus the lateral Biceps Femoris (ST-BFcl) activation balance during commonly used therapeutic exercises.

In a study by Zebis et al. (Zebis MK., et al., 2012) it was found that specific therapeutic exercises targeting the hamstrings can be divided into Semitendinosus (ST) dominant and Biceps Femoris (BFcl) dominant hamstring exercises. Kettlebell Swing (KS) and Romanian Deadlift (RD) targeted the ST specifically and at intensity levels able to stimulate muscle strength gains (Kraemer WJ., et al., 2002). The ST dominance of the two exercises may partly be explained by the fact that ST is, in contrast to BFcl, parallel fibered with long-fibre lengths and a high number of sarcomeres in series. This arrangement increases the total shortening capacity and absolute velocity of contraction for the ST muscle (Berne RM, Levy MN., 1993). Thus the potential to shorten at long distances is excellent for the ST muscle. During execution of KS and RD, the hamstrings are extensively stretched with the highest load in the most stretched position – that is hip flexed. Thus, we recommend these exercises when aiming at enhanced ability to recruit ST during forceful movements. In respect to a transfer effect to real-life sports activity, the KS may be superior to RD, due to a high-velocity training component. In contrast, the Supine Leg Curl and hip extension specifically targeted BFcl. Isolated leg curls using training machines are widely used and recommended in clinical rehabilitation after knee injury. Leg curl in a prone position has been reported to equally target the medial and lateral hamstring muscle, and the Seated Leg Curl has been reported to specifically target the ST (Oliver GD, Dougherty CP., 2009; Tesch P., 1993). Using a Biodex isokinetic dynamometer we did not detect any difference between the prone and seated leg curl in respect to the level of ST and BFcl activation (Zebis MK., et al., 2012). Thus, differences may exist between isokinetic and isotonic training devices. The main purpose of the balance/coordination exercises is developing a proper technique in the one-legged landing phase. The forward one-legged jump on both stable and unstable surface seems superior in respect to targeting the ST. The supervised balance/coordination exercise displayed peak ST and BFcl activity at different knee joint angles - ST EMG peaked at more extended knee joint angles – that is earlier in the landing phase (Zebis MK., et al., 2012) – which may represent a protection mechanism against dynamic knee joint valgus. Thus, the balance and coordination exercises may be important when aiming at establishing – and modifying existing – motor programmes. Although the latency of the ACL ligamentomuscular reflex arc (>100 ms) seems too long to provide a protective mechanism per se for the ACL in acute situations (Dyhre-Poulsen P, Krogsgaard MR., 2000), afferent feedback from the ACL potentially plays an important role in the updating and formation of pre-programmed motor patterns for optimising knee joint stabilisation (Johansson H., et al., 1991).

After ACL injury, the ligament is typically reconstructed by harvesting the ST tendon (Lind M., et al., 2009). Although the regeneration of the ST tendon has been confirmed in MRI studies, the volume of the ST in the reconstructed limb is significantly smaller than in the normal limb (Makihara Y., et al., 2006). Thus, atrophy and shortening of the ST after its tendon has been harvested, as well as insufficient compensation from the semimembranosus and biceps femoris, due to architectural and functional differences, makes it even more important, in terms of rehabilitating physical therapy, to introduce exercises with preferentially high levels of activation of the medial hamstring. However, to avoid adverse effects in the early phase of rehabilitation, caution must be taken when introducing high-intensity training among ACL reconstructed patients.

Conclusion

In conclusion, prophylactic training has been shown to reduce the incidence of ACL injuries among female elite team handball players. The prophylactic training used in team handball involves balance, coordination, strength and plyometric exercises. In addition, specific therapeutic exercises targeting the hamstrings can be divided into ST dominant or BF dominant hamstring exercises. In respect to the prevention of ACL injury, the ability to activate ST during forceful and explosive movements could be enhanced by ST dominant exercises like the Kettlebell Swing. However, further research is needed to examine the transfer effect to real-life sports activity, and to test the efficacy of the exercises in the prevention of injuries.

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HIGH INCIDENCE OF INJURIES IN HANDBALL: THE IMPACT ON PARTICIPATION AND SPECIFIC CONCERNS FOR THE FEMALE HANDBALL PLAYER

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Summary
This article will give an overview of the injury burden in elite handball primarily based on the only study that, until now, has assessed injury incidence, and handball exposure among handball players by the use of a SMS-system. The injuries impact on handball participation, and specific concerns for the female athlete will be further presented and discussed.

Keywords
Injury epidemiology; risk factors; European handball; female

Introduction

Handball, or team handball, is one of the most popular sports in Europe, played by men, women and children of all ages. Unfortunately, playing handball is also associated with a high risk of injuries. Long lasting injuries will inevitably have an effect on the players development of physiological and technical handball skills, and in some cases the injuries may be career ending and potentially have severe consequences later in life. In particular, serious knee injuries have been suggested as the main contributor to early development of osteoarthritis in the knee joint (Myklebust et al, 2003). For the national handball federations it is not only the quantity of injuries, but also the injury distribution and periods of vulnerability to injury amongst handball players that is concerning. If top players are injured at key moments in the season, it can mean the difference between the top of the podium and the back of the pack.

From all perspectives, it is therefore necessary to further investigate the injury mechanism, develop new effective preventive strategies, and implement the knowledge of the effective injury prevention strategies of these injuries.

An important first step in developing effective injury prevention strategies is to determine the true injury incidence and severity (Finch, 2006). To date all studies with systematic injury registrations of all types of injuries have been in recreational handball, and no studies have been performed in the elite handball population.

This article will present selected data from a Danish study using a new SMS injury surveillance method of injury registration in both youth and adult elite handball that allows injury reporting directly from the athletes themselves. Compared to previously used registration methods, the SMS injury surveillance system capture up to 66% more injuries (Nilstad et al, 2012) and facilitates more accurate exposure time, which allows us to obtain more accurate injury estimates. Secondarily, the aim was to investigate if gender and previous injuries are risk factors for new injuries. For further interest, please find other results already published in Møller et al (2012).

Material and methods

A 31-week prospective cohort study was conducted during the Danish 2010/2011 handball season (September, 2010- April, 2011), including 517 elite handball male and female players in the u-16 (n=194), u-18 (n=152) and senior (n=171) age groups. An elite player was defined as a player who was elected to play in the highest division at the beginning of the season for u-16, and u-18 players, and to the highest and second highest division for senior players.

Participants completed a web-survey establishing injury history, demographic information and sports experience, and provided weekly reports of time-loss injuries and handball exposure for 31 weeks by Short Message Service text messaging (SMS). Injuries were further classified by telephone interview.

The primary outcome was any handball related injury, which was defined as any physical complaints sustained by a player resulting from a match or handball training causing the player to miss a part of or the rest of the match and/or training sessions.

Results

Overall injury incidences

The overall injury incidence for the classified injuries was based on 448 injuries and 71014 hours and was 6.3 per 1000 match and training hours (95% CI 5.7-6.9). The injury incidence during match play was 23.5 (95% CI 17.8-30.4), 15.1 (95% CI 9.7-22.2), 11.1 (95% CI 7.0-16.6) injuries per 1000 match hours among senior, u-18, and u-16 players, respectively. In general, the study shows that reported injury incidence falls with age. However, the u-16 group had a 1.26 (95% CI 0.88-1.79) non-significant higher risk for overuse injuries compared to senior players.

Looking at the overall injury incidences we found no significant differences between gender among senior and u16 players. U-18 male players had an overall 1.75 (95% CI 1.10-2.80) times higher risk of injury compared to females.

Of all injuries, 165 injuries (37%) were classified as overuse injuries and 283 (63%) were as traumatic injuries. The most commonly traumatic injuries locations were the knee (19%) and ankle (29%), and the most commonly overuse injuries locations were the shoulder (15%), knee (21%) and shin splints (24%).

Injury severity: 20% percent of all players could not participate in handball activities every week

Injury severity was defined by the number of days the player was absent from handball activities. Approximately half of the injuries caused absence from handball activities more than one week: 33% caused absence from handball activities between 8-28 days, and 16% percent of all injuries caused absence in more than 28 days. Overall, this could be expressed as a weekly prevalence of injured players of 20 percent every week.

High incidence of recurrent injuries

Of the 448 classified injuries, the majority of the injuries were new injuries (65%), and 35% were recurrent injuries, of which 40% were classified as early recurrence (within 0-2 months), 29% as late recurrence (2-12 months) and 31% as delayed recurrence (>12 months).

A previous injury causing absence from handball activities for more than 4 week, was only a risk factor in the u16 group in particular if the player had sustained two are more previous injuries (IRR: 2.23 (95% CI 1.22-4.10)).

Gender-specific injury patterns

Woman had 1.93 (95% CI 1.09 to 3.42) higher risk of traumatic knee injuries compared to males after adjusting for previous injuries. This association was not significant when divided into age group, probably due to too few injuries.

No significant differences between gender were found for traumatic ankle injuries (IRR: 1.11 (95% CI 0.75 to 1.64)).

When examining the overuse injuries the female players were more at risk only with regard to shin splints with 4.19 times greater risk (95% CI 1.68 to 10.45) than male players. Conversely, female players were at lower risk of sustaining an overuse shoulder injury (IRR: 0.37 (95% CI 0.18 to 0.76)). Concerning overuse injuries of the knee, no gender differences were found (IRR: 0.60 (95% CI 0.19 to 1.88)).

Discussion

This study is the first of its kind in elite handball to capture all injury and exposure data using a SMS-system of self-report. A weekly response rate of 85-90% illustrates the promise of the SMS-system as an effective data collection tool in injury surveillance studies.

The estimated match injury incidence for senior players calculated by this study was 23.5 per 1000 match hours (95% CI 17.8-30.4), or more than twice that reported by Nielsen et al (1988). Senior male players had an estimated incidence of 31.8 per 1000 match hours (95% CI 22.6-45.0), which is nearly three times greater than the rates reported in previous studies (Petersen et al, 2002; Seil et al, 1998). In the u-18 group, the incidence of match injuries was 17.2 per 1000 match hours for males (95% CI 9.3-28.8), 13.0 per 1000 match hours for females (95% CI 6.5; 23.3). These rates were likewise greater than those in the study by Olsen et al. (2006). For u-16 players the estimated incidence of match injuries was 11.1 per 1000 match hours (95% CI 7.0-16.6). Only one previous study have reported data for u-16 players (Wedderkopp et al, 1997), but their results cannot be compared to our study due to differences in the injury definition. Reported incidences of training injuries and total incidence, based on both training and matches, were consistent with previously published reports in recreational handball for all age groups.

In this study, an injury was defined as injury causing time loss from sport, however, due to overuse injuries tend to have a gradual onset and often have fluctuating levels of symptoms and disability, a high percentage of the players continues to play with modifications rather than remove themselves from participating entirely, and the use of a time-loss definition, may have underestimated the overuse aspect of the injury spectrum because of the lack of inclusion for activity modification in this study (Bahr, 2009; Clarsen et al, 2012; Clarsen et al, 2013).

In a cross sectional study among elite women handball players more than 1/3 of all the players had problems with their shoulder, and 68% had changed their training volume due to shoulder pain (Myklebust et al, 2011). In contrary, only 10% of all injuries in this study were due to shoulder problems. This illustrates, that shoulder injuries, probably is a much more serious problem in handball for both woman and men, than previous reported.

Recently a new prospective registration method, that measure injury consequences beyond pure time-loss from sport, such as pain, altered participation and reduced performance have been developed (Clarsen et al, 2012; Clarsen et al, 2013). New, unpublished, results based on this registration method will be presented at the conference.

Are the players fully recovered after their injuries?
Previous injuries were only a risk factor in the u-16 group in particular if the player had sustained two or more previous injuries (IRR: 2.23 (95% CI 1.22-4.10)).

Wedderkopp et al. (1997) found a much higher relationship between previous injuries and new injuries (OR: 6.77 (95% CI 3.28-13.87)). This difference may be related to the differences in the injury definition between the two studies.

The high risk for re-injury, and the high number of early recurrence injuries emphasizes the need for clear criteria for return to sport. In soccer, one study found a 66% overall re-injury risk reduction (HR (0.34, 95% CI 0.16-0.72) and 75% lower limb re-injury risk (HR 0.25, 95% CI 0.11-0.57) when using clear criteria for return to sport, compared to a control group using no criteria for return to play (Hagglund et al, 2007).

Specific concerns for the female handball player
The most commonly reported traumatic injury locations were the ankle and the knee, 32% and 14% respectively, or 2.2 more ankle injuries than knee injuries. Wedderkopp et al. (1997) presented similar findings, but Olsen et al. (2006) and Seil et al. (1998) reported that the number of acute knee and ankle injuries were similar.

Gender was only a significant risk factor in the u-18 group, in which boys had a 1.75 (95% CI 1.10-2.80) times greater risk of injury than girls.

Looking at traumatic knee injuries, the female players had nearly twice as greater risk for injury, than compared to male players, although no gender differences was found with regard to ACL-injuries, due to small sample sizes. However, previous studies have shown that women have up to 5 times higher risk for an anterior cruciate ligament injury compared to men (Myklebust et al, 1998; Yoo, 2010).

Conclusion
The injury incidence of time-loss injuries among elite handball players is higher during match play than previously reported in recreational handball, however, it might be due to the new SMS-method implied as registration method in this study. Male players had a significant higher overall injury rate in the u-18 group. Female players had a higher risk for traumatic knee injuries and lower leg overuse injuries, while male players had a higher risk for overuse shoulder injuries.

Previous studies have shown that it is possible to prevent more than 50% of traumatic knee and ankle injuries. This study indicates, unfortunately, that prevention programs have not yet been effectively implemented in Danish elite handball clubs. Accordingly, a future challenge is to implement prevention programs proven effective to the coaches and athletes in sports.

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NEURO-MUSCULAR COORDINATION AND BALANCE SKILLS DEVELOPMENT IN YOUNG FEMALE HANDBALL PLAYERS

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Summary
In contemporary handball, we can observe a diversification of the shooting at the goal, as well as a continuous adaptation of the technical elements and procedures to the game circumstances. Neuro-muscular coordination and balance skills new ways of improving are treated as new trends in sport performance training process. Some researches show best efficiency in athletes that manage their body and segments in best coordinative circumstances.

Keywords
handball, coordination, motor skills.

Introduction
In the contemporary handball we can observe a diversification of the shooting procedures, as well as a continuous adaptation of the technical elements and procedures to the game circumstances. At the same time, we can observe an increase in the incidence and seriousness of injuries **(**Cartwright Lorin A., Pitney William A., 2005.).

Thus, to prevent injuries, and for a complex training of the athletes, several means of training are being searched and developed, to improve the athletes' performances, and also to maintain them in good health (Acsinte, A. et al., 2010).

One of the current tendencies is to introduce in the structure of the training sessions specific "proprioceptive training" elements, meant to improve the specific static and dynamic balance indices, as well as the neuro-muscular coordination starting in early ages (Acsinte A, et al., 2009.).

As a consequence, this paper tries to prove that the use of specific drills, using helping tools, can influence the above-mentioned indices, hence also the athletes' performances during official events.

An interesting aspect in our work was that the girls juniors has been more opened to the new drills we introduce, then boys.

Method and subjects
Six players from Girls juniors’ handball team of CSS. Bacau, age 13-14 years, took part to our research during six months. The procol consists in three training sessions 30 - 40 minutes each, per week, in addition of the main training programme schedule.

The selected drills has been developed using unstable surfaces devices such as Balancefit, Bossu, Foam devices etc. Evaluation of the athletes’ performances has been realized using tests from “Functional testing in Human Performance – 139 tests for sport, fitness, and occupational settings” by Michael P. Reiman and Robert C. Manske (Human Kinetics, 2009) (see Figures 1-3).

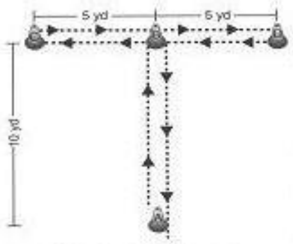


Fig. 1. "T – Test"

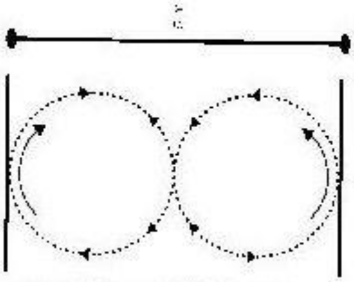


Fig. 2. "Figure 8" – hop test

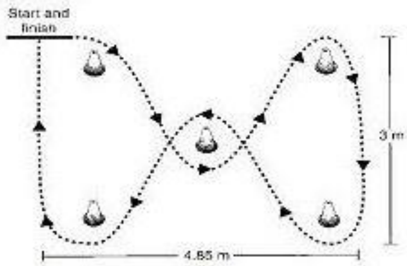


Fig.3. "ZIGZAG" Run test

Testing activity has been performed at the beginning of the preparatory period and the final one at the end of those six months. Results of each test are presented below.

Results:
Handball players has been tested with "T – Test" (Fig. 1), "Figure 8 Hop Test" (Fig 2) and "ZIGZAG Run Test" (Fig. 3). Results of testing protocols are presented in tables 1-4.

Table 1. *"T – Test" results (see Graph.1)*

Tested players by team positions	**Initial values**	**Final values**	**Mean**
Center Back	12.4	12.2	**12.3**
Line player (Pivot)	13.3	12.5	**12.9**
Left wing	12.1	11.1	**11.6**
Right wing	11.0	10.88	**10.94**
Left Back	13.6	12.4	**13.0**
Right Back	12.5	12.4	**12.45**
Mean	**12.48**	**12.09**	**12.19**

Graphic 1. *T-test mean values dynamic.*

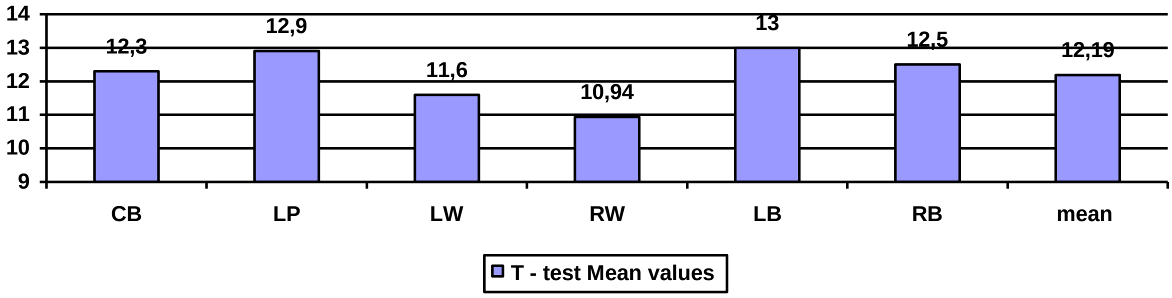


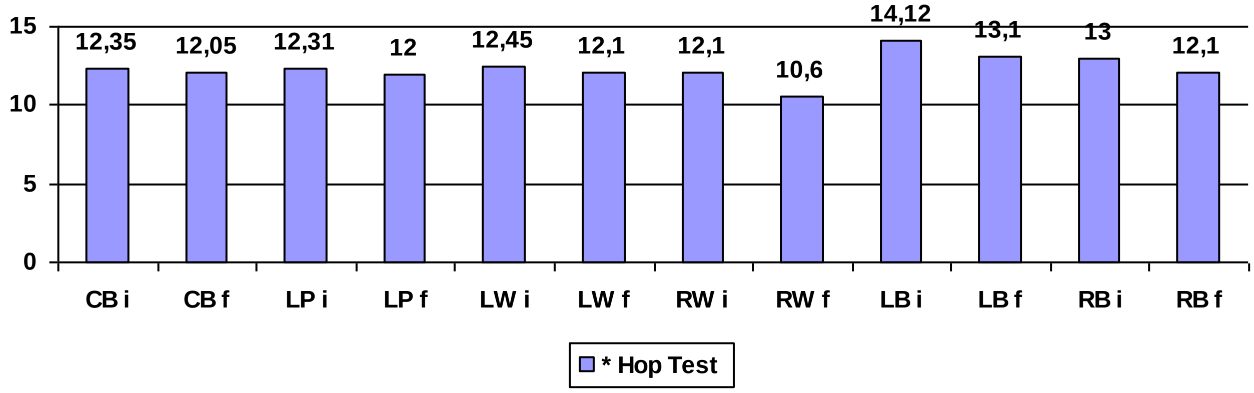
Table 2. *"Figure 8 Hop Test" results – initial values*

Tested players by team positions	**Dominant leg (sec)**	**Non-dominant leg (sec)**
Center Back	12.35	12.45
Line player (Pivot)	12.31	12.40
Left wing	12.45	12.55
Right wing	12.10	12.23
Left Back	14.12	14.20
Right Back	13.00	14.33
MEAN	**12.72**	**13.02**

Table 3. *"Figure 8 Hop Test" results – final values*

Tested players by team positions	Dominant leg (sec)	Non-dominant leg (sec)
Center Back	12.05	12.38
Line player (Pivot)	12.0	12.0
Left wing	12.10	12.45
Right wing	10.60	11.10
Left Back	13.10	13.00
Right Back	12.10	13.10
MEAN	**11.99**	**12.33**

Graphic 2. *"Figure 8 Hop Test " values dynamic – dominant leg.*



Graphic 3. *"Figure 8 Hop Test " values dynamic – nondominant leg.*

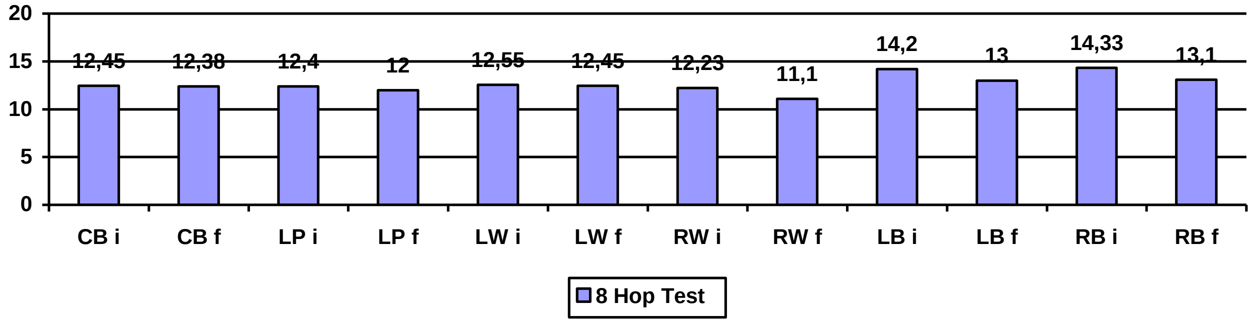
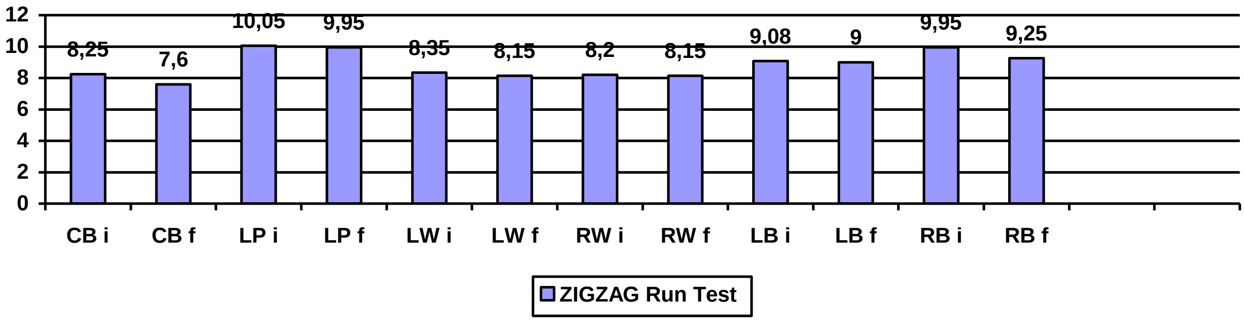


Table 4. *"ZIGZAG RunTest" results.*

Tested players by team positions	Initial values (sec)	Final values (sec)
Center Back	8.25	7.60
Line player (Pivot)	10.05	9.95
Left wing	8.35	8.15
Right wing	8.20	8.15
Left Back	9.08	9.00
Right Back	9.95	9.25
MEAN	**8.98**	**8.68**

Graphic 4. *"ZIGZAG RunTest" mean values dynamic*



Discussions

According to the results, we can appreciate the followings:

- "T" – test evaluation shows a good improvement in Left wing and Left Back players; we can not appreciate that the rest of results shows an important progress;
- "Zig-Zag" Run test – does not show any important progress, all of the improvement values are under one second; left wing, centre back and right back has better results from entire team;
- Dominant leg from "8 Hop" Test, recorded over one second only at two players (right wing and left back) and from nondominant leg we found three values over one second (right wing, left back, right back);
- Generally, the drills we selected determined a good progress in every player we work with.

Conclusions

- the values recorded during the "T" test proves that the players' reactiveness was relatively low; although the left wing record one second progress, the right wing had a progress of 0.12 sec., an important progress being recorded by the left back;
- we must emphasize the fact that the effect of the drills that were used has been felt more in the non-dominant leg (0.73 sec.), in comparison to the dominant leg (0.69 sec.);
- even if under one sec. progress recorded with regards to the "ZIGZAG Run Test", the dynamic and static balance indices were improved after the athletes performed the drills we selected; the ankle joint stability was also improved, this being confirmed by an increase in the fluency of the performance of specific technical drills (standing and moving passes), performed on different circumstances; this fluency has been confirmed by the increase in the number of performances within a given time;
- one important aspect is the progress of the left wing which is the only player with constant improved values; next players in order are centre back and pivot.
- Generally, we can say that different kind of specific drills, practiced constantly during separate training sessions has a very important influence at the specific handball motor skills. Starting with these structures at early ages, we can improve at the same time the joints stability and reduce the incidence of injuries in the player's future activity.

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LOAD INTENSITY OF FEMALE PLAYERS (AGED 17-18) IN NINE COMPETITION MATCHES IN HANDBALL

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Summary
The present study analyses the heart rate of fourteen elite handball female players of the highest competition in the Czech Republic during nine competition matches. The average heart rate of the monitored team was 183.5±7.1 beats/min and this value corresponds to 90.4±3.3 $\%HR_{mean.}$ Pivots had the highest average heart rate 185.8 beats/min which corresponds to 90.7 $\%HR_{mean}$. Pivot was the post of the highest load with spending 87 % of the playing time in the highest load intensity level (>85 $\%HR_{max}$).

Keywords
heart rate, performance, playing position

Introduction

Performance in variety of intermittent team sports has been linked to the participant´s speed, power, strength, agility, and sustained ability to repeat short high-intensity bursts of activity throughout a match, rather than the capacity to sustain a steady submaximal work rate (Bangsbo, Nørregaard, & Thorsø, 1991). In elite sports athlete's technical, tactical, physiological, and psychological/social characteristics play a fundamental role in development of a match performance. Regarding the physiological area, the tasks realized during a match define the physical demands for athlete's organism. Depending on the sport practised, these demands can be centred in the aerobic system, anaerobic system, or both. In team sports such as soccer and basketball athletes perform different types of exercise ranging from standing still to maximal running with varying intensity (Bangsbo et al., 2006).

Based on these findings of physiological load during the match, a lot of quantitative training methods have been developed to optimize team sports players´ performance. On the other hand, acquiring understanding the real play at these levels would allow us to design much more appropriate and specific conditioning and technical-tactical training sessions and even establish our own methodology. In addition, understanding the demands of team sport in its early stages would allow us to create training programmes which are much more in line with the somatic and maturative characteristics of girls in these age groups, and even improve sport's talent detection and selection criteria (Barbero Álvarez et al., 2007).

Optimal physical working demand analysis includes locomotion match analysis (movement category, intensity, distance) as well as technical match analysis (technical playing actions) (Michalsik, & Bangsbo, 2002). Handball is a kind of intermittent sport, similarly to some other kinds of intermittent sports such as rugby, soccer, hockey and basketball. During the intermittent sports matches players need to perform different types of exercise such as standing, jogging or maximal running (Lemmink, Verheijen & Visscher, 2004). The intensity therefore alternates at any time. As this type of sport needs to have intermittent exercise with both high-intensity and low-intensity, cardiovascular fitness is very important, too. Reilly and Seaton (1990) found that intermittent sports, such as field hockey, require a high degree of physical fitness. The physiological demands are complex in intermittent sports. Players need to have the ability to perform prolonged intermittent exercise. They also need to have the ability to exercise at high intensity, to sprint, and to develop high power output in single match situations such as kicking, jumping and tackling (Bangsbo, 1993). In conclusion, both aerobic and anaerobic fitness are important for intermittent players.

Team handball is an intermittent sport, where the players cover the distance of 4-7 km in various intensity during 60 min of the match (Chelly, et al. 2011; Póvoas, et al., 2012, Manchado, et al., 2013, Perš et al., 2002; Šibila, Vuleta, & Pori, 2004, Bělka, et al., 2012; Michalsik, Aagaard & Madsen, 2011). Because minimum of researches has been done in this field, the physiological demands in a women handball match are not defined exactly (Manchado, et al., 2013; Bělka, Hulka, Svoboda, & Kostelnik, 2011). Studies of Chelly, et al. (2011), Póvoas, et al. (2012), Manchado, et al. (2013) show that the average intensity of heart rate during a handball match is 82-86%$HR_{max.}$ However, the studies were either focused on male players or warm-up matches were monitored or the standard duration of the match was not played. The major objective of the present study is the analysis of junior female players' heart rate during nine competition matches.

We believe that our results will differ from other studies because of the specificity of the group and because the team was one of the best in its age category in the Czech Republic. The results should be used as specification of the game performance w.r.t. the load intensity of female handball players of a particular age category.

Methods

Subjects

Fourteen players from an elite junior female handball team from the Czech Republic participated in this study. The players had an average of 10 years' experience in this sport. The goal keepers were not involved in this study because their position requirements differed from those of the other players. All players were fully informed of the study and signed an agreement to participate. The average age of the players was 17.9±0.3 years; average height was 169.6±6.9 cm; average mass was 65.4±6.9 kg. The players practiced five times per week for an hour and a half and played a competition match once per week. During the 2011/2012 season, nine competition matches (five home matches and four away matches) were analysed. The team involved in this study took the second place in the Czech Republic elite junior handball league. The team included one senior and one junior player who played in the Czech national team.

Table 1. *Antropometric characteristics of participants*

Playing position	n	Age (years)	High (cm)	Mass (kg)	BMI (kg/m^2)	VO_{2max} (ml/kg/min)
Wings	5	17.8±0.4	169.4±6.7	62.4±3	21.8±1.5	42.9±2.6
Backs	7	17.9±0.3	170.9±7.3	66.7±8.8	22.8±5.6	48.7±5.6
Pivots	2	18±0.0	166.2±4.1	68.1±3	24.8±2.3	44.6±4.1
Total	14	17.9±0.3	169.6±6.9	65.4±6.9	22.7±2.1	46.05±5.2

Heart rate

The players' heart rates were monitored during all nine matches in regular five-second intervals using TEAM Polar^{2}Pro sporttesters (Polar Electro, Kempele, Finland). Heart rate were successfully monitored for all players in all matches, and the match was defined in terms of playing live time (i.e., the complete time the players were on the court without any interference from half-time, timeouts or bench time).

The maximum heart rate was measured by means of Yo-Yo intermittent level 1 (YYIRT1) recovery test (Bangsbo et al., 2008) and was established to each player individually (Krustrup et al., 2003). The measurements were done in a sports hall on a handball court. All players were already aware of this test, since they are used to undergoing it as a part of a conditioning test before and during a season. The value of an individual maximum heart rate (HR_{max}) was used as a standard against which three intensity zones (<65 % HR_{max}, 65 to 85 % HR_{max}, >85 % HR_{max}) were defined.

The relative time was divided into three zones with different load intensity. These zones were based on Woolford and Agove's (1991) classification and included supramaximal or high-intensity activity (>85% HR_{max}), aerobic zone or medium-intensity activity (65 to 85 %HR_{max}) and sub-aerobic or low-intensity activity (>65 %HR_{max}). Based on these classifications, Barbero, Soto, Barbero & Granda, (2008) presented a similar study about futsal. Our gathered data were analysed using Polar Team[2] Pro software (Polar Electro, Kempele, Finland). We computed average time covered in each zone for each match as well as the average heart rate (HR_{mean}) and HR_{max} of each player. These modes were presented as both absolute (beats per minute [BPM]) and relative values (percentage of maximum heart rate [%HR_{max}] and average heart rate [%HR_{mean}]).

Match analysis
All nine monitored competition matches were played on high-quality indoor courts with parquet and polyurethane (synthetic rubber) floors. The temperature in the sports hall ranged from 21 to 23 °C during the matches. The matches consisted of two 30-minute periods with a 10-minute half-time. The monitored team won seven matches and lost two matches. The monitored team varied between two defensive systems (0:6 and 1:5) and preferred the offensive system which used only one pivot.

The players' motions were recorded with two digital camcorders (Panasonic SDR-H80 and Canon HF10) during nine competition matches at the beginning of the season and then throughout the season. Five home and four away matches were analysed. Only three of the participants did not play in all six competition matches. 12 players who participated and were regularly substituted in each match were analysed. The time the players spent in the first half on the court was on average 14±3.2 min (range = 11–20 min) and in the second half 14.5±2.8 min (range = 11–22 min). During the whole match the players spent on average 29.15±5 min (range = 21 – 38 min) on the court. The fact the players were substituted regularly resulted in a higher heart rate.

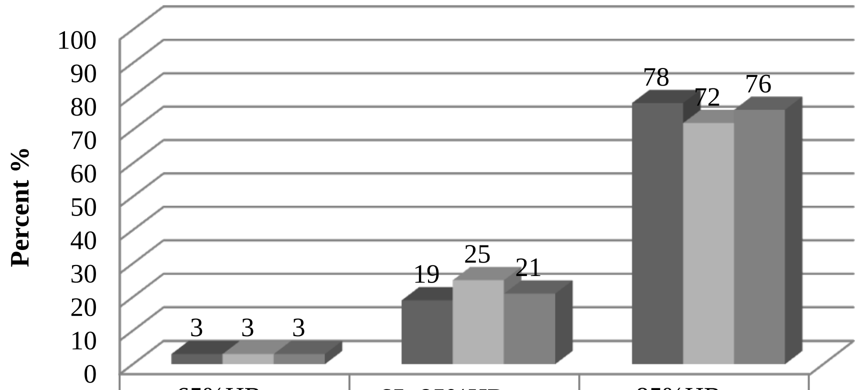
Statistical analyses
To gather, adjust and analyse the data and to compute all statistical characteristics, we used statistical software package Statistica 10cz (StatSoft Inc., Tulsa, OK, USA). The data are presented as arithmetic means, standard deviations (s) and ranges. The average motion and heart rate values measured during the matches were compared. To compare data collected about heart rate one-way ANOVA with repeated-measures was used. The statistical significance was set at $p < 0.05$.

Results

Heart rate

The players scored 31 goals and they had the scoring success of 59 %. They made 10 technical errors on average (steps, attack faults, double dribbling, wrong pass, entering goal area etc.) and they were penalized by 2 minutes twice on average. There were 63 attacks on average.

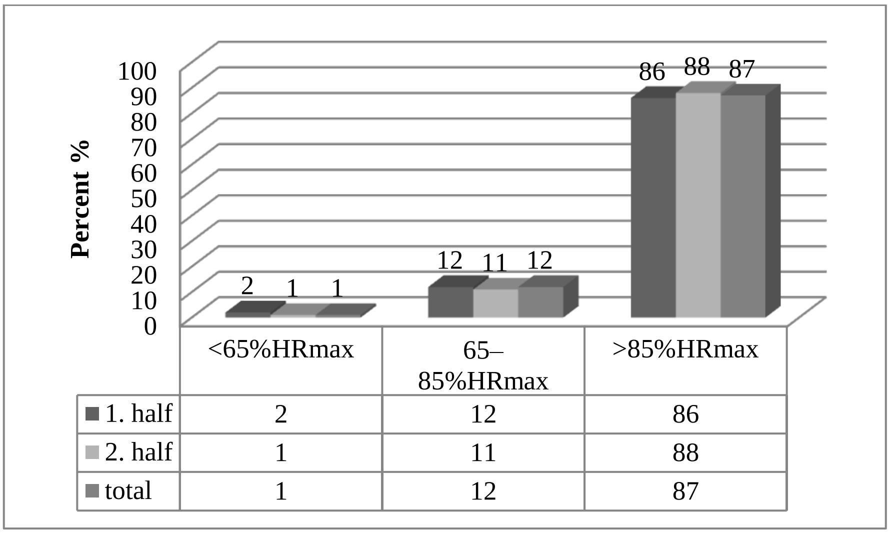
The average heart rate of the monitored team was 183.5±7.1 beats/min and this value corresponds to 90.4±3.3 $\%HR_{mean.}$ The average heart rate of the players in the first and the second half-time was 184.7±7.3 beats/min., more precisely 182.2±6.8 beats/min corresponding to 91.1±3.6 $\%HR_{mean,}$ more precisely to 89.8±3.3 $\%HR_{mean}$. No statistically significant ($F=2.02$; $p=0.16$) difference between the first and the second half-time occurred. The players spent 76 % of the playing time in the load intensity level >85 $\%HR_{max}$. The players spent 3 % of the playing time in the lowest load intensity level (<65 $\%HR_{max}$) (Picture 1). No statistically significant difference between the first and the second half-time occurred in any zones of load intensity.



	<65%HRmax	65–85%HRmax	>85%HRmax
1. half	3	19	78
2. half	3	25	72
total	3	21	76

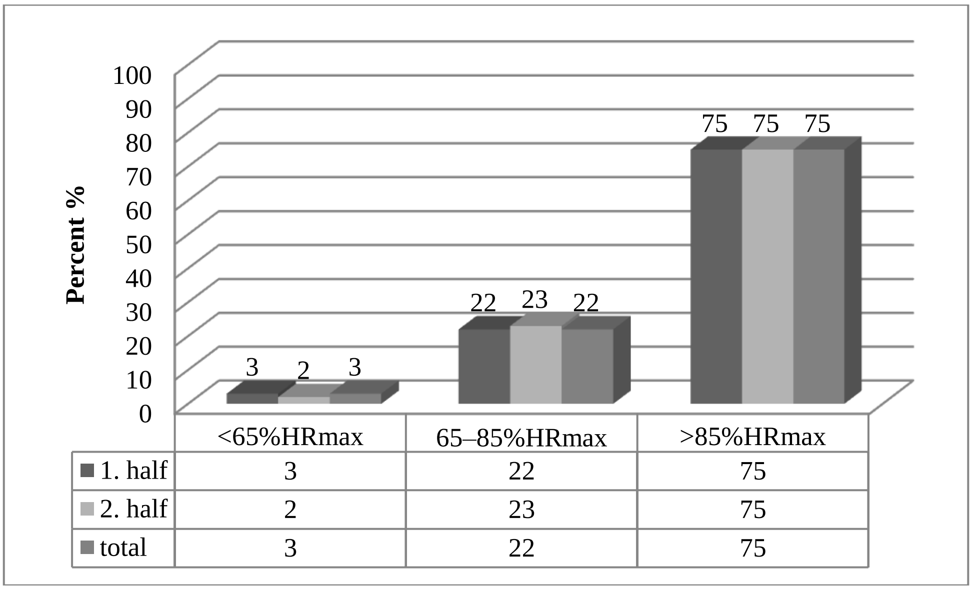
Picture 1. *Time spent by the players in particular zones of load intensity in particular half-times and during the whole match expressed as a percentage.*

The pivots scored 5 goals in a match on average and their scoring success was 67 %. They made one technical error in a match on average. The pivots had the highest average heart rate 185.8±8.8 beats/min which corresponds to 90.7±4.4 $\%HR_{mean}$. The pivots' average heart rate was higher in the first half-time than in the secong half-time (186.2±8.5 resp. 183.8±8.8 beats/min). The average heart rate intensity was 91.3±4.3 $\%HR_{mean}$ in the first half-time and 90.1±4.4 $\%HR_{mean}$ in the second half-time. No statistically significant ($F=0.307$; $p=0.59$) difference between the first and the second half-time occurred. Pivot was the post of the highest load with 87 % of the playing time spent in the highest load intensity level (>85 $\%HR_{max}$). The pivots spent extra 2 % of time in the zone of load intensity over >85 $\%HR_{max}$ in the first half-time in comparison with the second half-time. No statistically significant difference between the first and the second half-time occurred in any zones of load intensity.



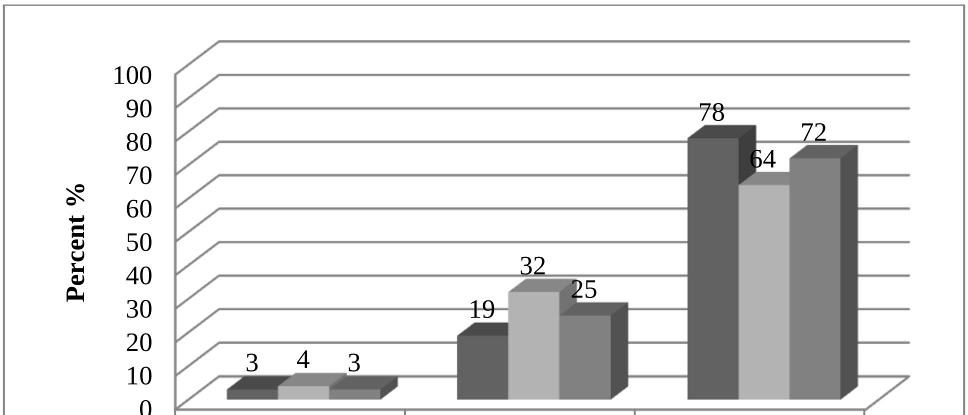
Picture 2. *Time spent by pivots in particular zones of load intensity in particular half-times and during the whole match expressed as a percentage.*

The scoring success of the wings was 68 % in the monitored matches, when scoring 7 goals per match on average. They made two technical errors in a match on average. The wings had the average heart rate 183.8±6.2 beats/min, corresponding to 90.5±3.2 $\%HR_{mean}$. The average heart rate was higher in the first half-time in comparison with the second half-time. The average heart rate of wings in the first and the second half-time was 184.9±6.2 beats/min resp. 182.7±6.1 beats/min, corresponding to the average heart rate intensity 91.1±3.1 $\%HR_{mean}$ resp. 89.9±3 $\%HR_{mean.}$ No statistically significant (F=0.81; p=0.38) difference between the first and the second half-time occurred. Wings spent 75 % of the playing time in the load intensity level over >85 % HR_{max} (Picture 3). No statistically significant difference between the first and the second half-time occurred in any zones of load intensity.



Picture 3. *Time spent by wings in particular load intensity levels in particular half-times and during the whole match expressed as a percentage.*

The centres were the most shooting posts in the monitored matches, when shooting 36x to the opponent's goal on average and having the scoring success of 55 %. They made seven technical errors (steps, attack faults, double dribbling, wrong pass, entering goal area etc.) during the match. The average heart rate of the backs was 182.9±7.5 beats/min corresponding to 90.1±3.7 $\%HR_{mean}$. The average heart rate of the backs in the first half-time was 184.1±7.7 beats/min corresponding to 91.1 $\%HR_{mean}$, which was higher when contrasted to the average heart rate in the second half-time 181.7±7.2 beats/min corresponding to 89.3 $\%HR_{mean.}$ No statistically significant ($F=1.03$; $p=0.32$) difference between the first and the second half-time occurred. The backs spent the least amount of time in the load intensity level over >85 % HR_{max} during the match. The largest decrease occurred in the second half-time where the becks spent 64 % of time in the load intensity level over >85 % HR_{max} (Picture 4). No statistically significant ($F=0.34$; $p=0.56$) difference between the first and the second half-time occurred. No statistically significant difference between the first and the second half-time occurred in any zones of load intensity.



	<65%HRmax	65–85%HRmax	>85%HRmax
1. half	3	19	78
2. half	4	32	64
total	3	25	72

Picture 4. *Time spent by becks in particular load intensity levels in particular half-times and in the whole match expressed as a percentage.*

Discussion

Considering the load intensity from a physiological point of view, our heart rate results were higher (183.5±7.1 beats/min; corresponding to 90.4±3.3 of $\%HR_{max}$) compared with similar studies, such as Chelly et al. (2011), Platen and Manchando (2011), Manchado et al. (2013), Michalsik, Madesn a Aagaard (2011). In their study Chelly et al. (2011), found out the heart rate of 15-year-old players to be 172±2.1 $beats \cdot min^{-1}$, corresponding to 82±3 of $\%HR_{max}$. In a study Platen and Manchando (2011) found a slightly lower average heart rate of 161.7±11.9 $beats \cdot min^{-1}$; however, when they measured older players, the average heart rate ($\%HR_{max}$) was higher (85.8±3.2 $beats \cdot min^{-1}$). The average $\%HR_{max}$ is lower also in the studies of Manchado et al. (2013) and Michalsik, Madesn and Aagaard (2011). In the study of Manchado et al. (2013), the average heart rate intensity is 86.5±4.5% of HRmax and the players spent 65 % of time over 85 $\%HR_{max.}$ Michalsik, Madesn a Aagaard (2011) The average heart rate intensity was even lower in Michalsik, Madesn a Aagaard's (2011) study when being of the value of 79.4±6.4 % of $HR_{max.}$ Póvoas, S., C., A., et al. (2012) detected the average heart rate intensity of female handball players during a match 82±4.5 % of $HR_{max.}$

In any case, we have to be careful while interpreting our result, since HR can be affected by several factors not considered in this study. Among them we could mention nutrition, hyperthermia, dehydration, many psychological factors such as anxiety and motivation, performance, and regular substitutions. Contrasting results have been reported in the literature, showing either a significant decrease or no change in heart rate between the first and the second half of games in various team sports (Bangsbo & Lindquist, 1992; Coutts et al., 2003). No significant decrease in high intensity activity was found neither in the second half (>85 $\%HR_{max}$) nor in the average heart rate intensity.

The overall aim of high intensity training is to increase the work-rate during competition, and in ball games also to minimize a decrease in technical performance as well as lapses in concentration induced by fatigue. The specific aim of high intensity training in team sports is to improve the ability to recover after a period of high-intensity exercise. As a result, an athlete could be able to recover after high intensity actions in shorter time and consequently, be ready to perform at this intensity throughout the whole match (Bangsbo et al., 2006).

Conclusions

Our results showed that the most loaded game post in the match is the pivot. Above all, it is because of his specificity during the match when he occurs in permanent contact with his opponents considering offence as well as defence. He is also often engaged in the first wave of fast offence, but that depends on the team's tactics. No significant average intensity heart rate decrease appeared in any of the game posts between the first and second half-time. The backs proved the largest decrease in the time spent over > 85 $\%HR_{max}$ between the first and second half-time.

We would recommend putting specific exercises of anaerobic character and methods of high interval training into the training process of female junior players because their average heart rate occurs at 90 $\%HR_{max}$ and the players move above the border of 85 $\%HR_{max}$ nearly 45 min. The players' organism should be adapted enough to the high intensity load, which is necessary to be kept throughout the first and the second half of the match at the same level.

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EVALUATION OF THE TALENT IDENTIFICATION PROGRAMME OF THE GERMAN HANDBALL FEDERATION

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Summary
One of the main and probably most important and difficult tasks in youth handball is the identification of talent. Therefore, an alliance of practitioners and researchers evaluated the modified talent identification programme of the German Handball Federation. The results indicate that, temporary, the best predictor distinguishing between nominated and non-nominated female youth players is the ball throwing velocity. Additionally the predictive validity for youth national teams is quite low, but long term analyses (adulthood) will follow.

Keywords
Team nomination, prognostic validity, discriminant function analysis, ball throwing velocity

Introduction

One of the main and probably most important and difficult tasks in youth handball is the identification of talented athletes (cf. Baker, Cobley, & Schorer, 2012). Coaches are asked to basically to predict future performance of young athletes on the basis of tests developed with or without sport science research (cf. Schorer & Elferink-Gemser, 2013). For example, the German Handball Federation (DHB) conducts a talent identification programme (TIP) with female (15-16 years) and male (16-17 years) youth handball players each year. To improve the quality of the tests used to make those predictions, our research group worked together with the German Handball Federation. There are currently two approaches for identify potential predictors during talent identification: (1) the ability approach and (2) the expertise approach (cf. Hohmann, 2009). The main idea of the first approach is to measure abilities like speed, endurance or coordination, with the assumption that those more gifted in these abilities will be better in developing later superior skills (cf. Schneider, Bös & Rieder, 1993). This focus is on talent diagnosis. For the expertise approach differences between highly skilled and less skilled adult athletes are identified (cf. Elferink-Gemser, Vischer, Lemmink & Mulder, 2004, 2007). Those differences – for example differences in anticipation or ball throwing velocity – are then used to create tests that should be able to help in talent prognosis. Both approaches have their strengths and their weaknesses, which is why a combination of both approaches should be used in current talent identification programmes.

In 2008, the DHB launched a combined and therefore modified TIP utilizing anthropometric, motor, and psychological tests hoping to improve the prognostic validity of the talent identification process (Schorer, Büsch & Strauß, 2012; Schorer et al., 2013). To evaluate this new talent identification programme, an alliance of practitioners and researchers was formed. In the beginning this was partly funded by the Federal Institute of Sport Science (IIA1-070704/09-10), the Institute for Applied Training Science and the German Handball Federation. These enabled us to develop several tests that had not been used previously. The aim of this alliance, and also of this study, was to evaluate the modified talent identification programme in general and especially the prognostic validity of the different tests. Therefore, we investigated whether these tests differentiate between youth team players nominated and not-nominated by the national coaches.

Methods

The female youth handball players from 20 regional selection handball teams spanning from 2008 to 2013 (N = 240 per year) performed a series of anthropometric, motor and psychological tests. We administered anthropometric and motor tests like hand size (Barut, Demirel, & Kiran, 2008; Visnapuu & Jürimäe, 2007; 2008), handgrip strength (Barut, et al., 2008; Leyk, et al., 2007; Visnapuu & Jürimäe, 2007), maximal feet tapping frequency (Voss, Witt, & Werther, 2006), and handball specific jump tests (Pielbusch, Marschall, Dawo, & Büsch, 2011). The psychological questionnaires included questions on achievement motivation (Schorer, Baker, Lotz, & Büsch, 2010), coping strategies (Smith, Schutz, Smoll, & Ptacek, 1995), as well as motor and handball specific self-efficacy (Wilhelm & Büsch, 2006; Wilhelm, Büsch, & Pabst, 2012). Additionally, players were observed while playing varying forms of handball. Based on regional and national coaches' ratings on prognostic validity and internal consistency of these tests, the number of items for the following analyses was reduced to 16 potential predictors: 30m sprint, jump and reach, ball throwing velocity, shuttle run, throwing precision under time pressure, dribbling, medicine ball throwing, hand-grip strength, standing long jump, push-ups, sit-ups, body height, body weight, achievement motivation, coping, and self efficacy. Current nomination (nominated vs. non-nominated) by the national coaches was used as our grouping variable.

Stepwise discriminant function analyses were performed separately for each year using motor, psychological, and anthropometric variables as predictors of membership in two groups, i.e. nominated versus non-nominated by the national coaches for the next step for the youth national team.

Results

Of the original N = 240 cases every year, several were dropped by analysis because of missing data. Missing data appeared to randomly scattered throughout predictors and groups as well as no outliers were identified so that full data sets include $212 \leq N \leq 223$ cases. Although, predictors were not identical every year because several predictors did not reveal normality of sampling distributions of means testing by the Kolmogorov-Smirnow adaptation test. For the remaining predictors, evaluations of assumptions of linearity, normality, multicollinearity, and homogeneity of variance-covariance-matrices reveal no threat to multivariate analysis.

In 2008, the best predictors were 30m sprint, *Wilks'* λ = .93, $F(1, 210) = 16.03$, $p < .001$, and ball throwing velocity, *Wilks'* λ = .88, $F(2, 209) = 13.65$, $p < .001$, with a correct classification probability of 75.3 %. The nominated player were better in sprinting, $t(217) = 3.92$, $p < .001$, $g = 0.45$ ($CI_{90\%}$: 0.14 – 0.75), and throwing, $t(217) = 4.08$, $p < .001$, $g = 0.35$ ($CI_{90\%}$: 0.05 – 0.66). The summarized results from 2008 until 2013 suggest with a high correct classification probability (> 75.3%) that the best predictor distinguishing between nominated and non-nominated female youth players is the ball throwing velocity (see Table 1). No other predictors would have improved the percentage of correct classification.

For practical recommendations, we performed the analyses by computing the receiver operating characteristic curves and Jouden's J statistic. The discrimination threshold between sensitivity (true positive rate or hit rate of nomination) and specificity (false negative rate or rejection rate of nomination) was determined by Jouden's index. This index value represents the ball throwing velocity the female handball players should achieve to have a serious chance for nomination. A ball throwing velocity between 64.5 and 73.5 km/h by a maximum ball throwing velocity between 82.0 und 90.0 km/h seems to be the discrimination range with the highest benefit.

Discussion

The results indicate that the identified tests per year change quite frequently. This is surprising, because most research assumes that once predictors are identified they can be used for future talent identification programmes. The need for replications of previous studies becomes obvious by our data. Some parts of the variation in the predictors in the two-year rhythm might be explained by relative age effects (Schorer, Wattie, & Baker, 2013). Within the older year group the coaches might look for other characteristics than in the relatively younger age group, but that is a hypothesis to be tested.

A second point that needs to be discussed is the quiet low predictive validity. In our current study we tried to identify the correct classifications for the nomination by the national coaches. This is a step we can conduct currently, but in the long run, that correct prediction of success of those talents when they are adults is of importance. We plan to run those analyses as soon as the athletes have reached the appropriate age for those analyses. This also raises another perspective on this study. We currently use group statistics to identify predictors of later success. Given that for the adult national team not more than a handful of players will be of interest, other analyses might be more appropriate that look for outliers rather than for means.

Of course, we cannot rule out the possibility that the identified predictors are just not sensitive and specific enough (Lidor et al., 2005). In most expertise studies the comparisons are between experts and novices. As advocated by Abernethy, Thomas, and Thomas (1993) more comparisons should be conducted between experts and near-experts. This would increase the variance between groups as well as decrease the variance within groups and would reflect more the primary variance we face in talent identification programmes.

Year	Correct classification	Predictors	Wilk's λ	F	df	p	t	df	p	1-β	g	$CI_{90\%}$
2008	75.3%	30 m sprint	0.93	16.03	1, 210	< .001	3.92	217	< .001	> .99	0.45	0.14 - 0.75
		ball throwing velocity	0.88	13.65	2, 209	< .001	4.08	217	< .001	.98	0.35	0.05 - 0.66
2009	84.1%	ball throwing velocity	0.92	9.65	1, 212	< .001	3.74	224	< .001	.97	0.66	0.36 - 0.95
		body mass	0.94	13.72	2, 211	< .001	0.7	236	.49	.18	0.12	-0.41 - 0.17
2010	90.4%	ball throwing velocity	0.87	32.43	1, 209	< .001	5.74	216	< .001	> .99	1.08	0.76 - 1.40
		body height	0.83	21.68	2, 208	< .001	4.56	216	< .001	> .99	0.86	0.54 - 1.18
		30 m sprint	0.8	16.97	3, 207	< .001	3.41	217	0.001	.97	0.64	0.33 - 0.96
2011	81.9%	ball throwing velocity	0.93	17.25	1, 227	< .001	4.35	232	< .001	> .99	0.70	0.42 - 0.97
		standing long jump	0.89	13.54	2, 226	< .001	3.56	235	< .001	.96	0.57	0.30 - 0.84
		30 m sprint	0.88	10.45	3, 225	< .001	0.73	233	.47	.18	0.12	-0.34 - 0.17
2012	86.1%	ball throwing velocity	0.87	30.73	1, 213	< .001	4.93	223	< .001	> .99	0.89	0.58 - 1.20
		standing long jump	0.83	21.54	2, 212	< .001	4.65	227	< .001	.96	0.84	0.54 - 1.15
2013	82.8%	ball throwing velocity	0.92	30.73	1, 102	< .001	4.35	213	<. 001	> .99	0.75	0.45 - 1.06

Table 1. *Results of the discriminant function analysis and t-tests as well as the effect sizes with confidence intervals*

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OPTIMAL WEIGHT FOR A FEMALE HANDBALL PLAYER

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Summary
Recent studies indicate that, when pressure to achieve a weight goal is high, elite female handball players are likely to attempt any weight-change method to achieve success. Weight loss can be especially problematic in women both for health and performance. This may result in disordered eatings, menstrual dysfunction and stress fractures which are the features of what is called « the female athlete triad ».

Keywords
body composition, eating disorders, menstrual dysfunction, stress fractures

Introduction
Coaches and athletes today are acutely aware of the importance of achieving and maintaining optimal body weight for peak performance in sport. In complex sports such as HB a high body weight may be either an advantage in case of contacts, or a disadvantage when running, sprinting or jumping. Thus a high power-to-weight ratio is extremely important. Therefore, increasing lean-body mass and increasing body weight without increasing body fat is often desirable. Although size and body build can be altered only slightly, body composition can change substantially with dieting and exercise. Resistance training can increase muscle mass, and sound dieting combined with vigorous exercise can significantly decrease body fat.

Nevertheless, achieving an optimal body composition is more difficult in women than in men. When matched for size, body fat is higher in women than in men and increasing muscle mass with training is more difficult for women. To reduce their fat mass and reach idealised body shape, some female handball players use harmful fat-loss practices which may alter both performance and health.

Definition and assessment of body composition
Assessment of body composition is then critical to give players adequate recommandations. Standard height-weight tables do not provide accurate estimates of what an athlete should weight because they do not take into account the respective part of body fat and fat-free mass which reflect body composition. However body-fat assessment techniques also have inherent variability, thus limiting their precision.

Many laboratory techniques have been developed in the past, each of them with advantages and limitations. Besides densitometry which has long been the technique of choice, other laboratory techniques are now available among which DEXA (dual-energy X-ray absorptiometry). DEXA provides a digital image of the scanned body, displaying not only skeletal bone, but also soft tissues. DEXA is now recognized to give precise estimates of body composition. The disadvantage is the cost of the equipment and technical support as well as its availibility. The bioelectric impedance analysis, when performed in laboratory with adequate equipment, also gives correct estimation of body fat. But this technique requires time and strict conditions which are not achieved with usual bathroom weighing scales.

The most widely applied field technique involves measurement of skinfold thickness in 3 or 4 sites. This method only gives an estimation of body fat percentage with inherent variability and precision. It is a reliable estimation of body composition change over a period of time when the test is carried out by the same person with the same technique.

Body composition of female handball players

Data concerning body composition of female handball players remain scarce. Most of the data published are limited to anthropometric measurements and then to calculation of body mass index (BMI) which is calculated from size and weight only. Most BMI values either measured in national team or in medium class players lie in the range between 22 and 28kg/m^2 (Bayios et al. 2006). However BMI is not a good index of body composition especially in very active and trained people who have a higher muscle mass. Results of Milanese et al. (2011, 2012) report that elite and sub-elite female handball players exhibit different relative body fat despite very similar BMI (table1). As a consequence, elite female handball players which overwhelm 15 hours of training per week may have relative body fat values just around and even below 22% which is a very critical value. Of course, values also differ depending on playing position on the field. Body fat percent may be high in female goalkeepers. But according to Milanese et al. (2012) much lower values are found in pivot, back and wing female handball players.

Table 1: *Body composition of female handball players (literature data).*

Number	Elite 26	Sub-elite 17	A1 and A2 division 222
Country	**Italy**	**Italy**	**Greece**
Data from	**Milanese et al.(2011)**	**Milanese et al.(2011)**	**Bayios et al. (2006)**
Age (years) **Hours of training/wk** **Height (cm)** **Mass (kg)** **BMI (kg/m2)** **% fat**	**26.4 ± 5.77** **#24** **169.2 ± 6.04** **67.0 ± 7.91** **23.4 ± 5.33** **23.3 ± 5.33**	**17.3 ±2.25** **#16** **166.0 ± 5.10** **64.4 ± 10.47** **23.3± 4.01** **28.6 ± 4.01**	**# 15-30** **# 6-10** **165.9±6.3** **65.1±9.1** **23.6±2.7** **25.9±3.3**

Health and performance consequences of low body fat in women

Low relative body fat is a common feature in trained people and often results of restrictive food intake and high exercise-energy expenditure. Study of Sundgot-Borgen and Klungland-Torstveit (2007) indicates that 22,4% of female handball players exhibit eating disorders. This value is slightly lower to that of endurance female athletes (25.7%) and much higher to that of female football players (5.9%). In this study 7% of the female handball players also met the criteria for anorexia nervosa.

As soon as 1974, Frisch and McArthur theorized that the onset of menarche is achieved when body fat reaches a “critical threshold”, namely 17% of body weight and that menstruation is disturbed when body fat falls below the “critical threshold” of 22% of body weight.

According to Frisch's theory, a normal reproductive function depends upon fat percentage. Thereafter many studies demonstrated that adipose tissue is not only a tissue of fat storage but also an endocrine tissue able to secrete hormones like leptin. Leptin is a crucial hormone both involved in appetite control and in reproductive function. When body fat is too low, leptin secretion is altered which compromises secretion of sexual female hormones (oestrogens and progesterone), ovulation and menstrual function in women. For Sundgot-Borgen and Klungland-Torstveit (2007), the prevalence of menstrual dysfunction would reach 18.8% in elite female handball players.

Moreover chronic low oestrogens level is well recognized to alter bone mass and to increase risk of stress fractures. In the same study, the prevalence of stress fractures is much higher (23.2%) for female handball players than for endurance athletes (13.4%). Of course pivot, back and wing female players who train more than 15-20h/wk are at higher risk

Disordered eatings, menstrual dysfunction and low bone mass are the features of what is called « the female athlete triad » (Roupas and Georgopoulos 2011). Prevalence of this triad is largely underestimated. Indeed, most women refer to the absence of menses as a pleasant convenience and the loss of body mass is a very silent process until a related injury such as a stress fracture occurs. Use of oral contraceptive is now frequent in female « athletes ». According to Sundgot-Borgen and Klungland-Torstveit (2007) 43.9% of elite female handball players take contraceptive pills. Unfortunately this use masks the signs of mentrual dysfunction and benefits on bone mineral density still remain debatable (Cobb et al. 2007).

Of course, performance is also affected. Inadequate food intake reduces carbohydrate availibility which leads to reduced skill and judgment, causing the player to make more errors during the game and to be less efficient.

Responsible factors

Psychological, biological and social factors are involved in the development of the "female athlete triad". According to Sundgot-Borgen (1994) risk factors include restrained eating, frequent weight-cycling, early sport-specific training, personality factors, a sudden increase in training volume and the impact of coaching behaviour... In addition to the pressure to reduce weight, female players are also often pressed for time and have to lose weight rapidly to stay in the team. Weight-cycling has been suggested to be an important risk of trigger factor for the development of eating disorders (Brownell et al. 1987).

Conclusion

Optimal body-fat levels vary depending upon the sex, age, and heredity of the athlete, as well as the sport itself. No accepted standards exist for athletes The ideal body composition should be discussed on an individual basis with the player, physiologist, and nutritionist or dietician. A healthful weight is one that can be realistically maintained, allows for positive advances in exercise performance, minimizes the risk of injury, and reduces the risk for chronic disease.

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LIVE EXERTION EVALUATION IN ELITE HANDBALL REFEREES

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Summary
The purpose of this study was to evaluate the bioenergetic and neuromuscular demands of high level handball refereeing. We found a strong physiological response but no matching physical exertion. We think this is stress induced so the relation between stress management and decision-making accuracy should be further investigated.

Introduction
In handball, like in many other invasion sports, the referees must be physically fit to be able to accompany the match, maintaining a correct position throughout the game. This fitness must also avoid reaching levels of fatigue or physical exhaustion which may disturb the ability to make decisions (Castagna et al., 2007). However, few studies (da Silva, 2010) have quantified the physical demands imposed to handball referees.
In this work, part of a larger project, we measured with several methods - displacement velocity, HR, acceleration – the physical exertion of referees in a live situation and compared it with field tests (shuttle run) and standard laboratorial evaluations (anaerobic threshold) of the same subjects.

Methods
Sample
Ten referees (8 male and 2 female), 6 with EHF-level2 and/or IHF certifications and 4 EHF candidates, were involved in this study. The vital statistics are: age = (27 ± 2) years; body mass = (73.6 ± 8) kg and height = (173 ± 8) cm.

Procedures
During the final phase (3 days - 9 matches) of the Portuguese Supercup (January 2011) the referees were equipped each with tri-axial accelerometers (10bit/128Hz) and a two channel ECG device (10bit/256Hz). Additionally two fixed aerial cameras were placed in the arena ceiling. Extensive video data was obtained and processed with a new method for almost real-time video content extraction, with a linear accuracy of 16 cm (Santiago et at., 2012). An example of this data (planar coordinates of both referees) is plotted in Figure 3, representing the displacement of both referees. From this data we computed the full range of kinematic quantities: total distance covered by each referee, instantaneous velocity, etc.
Additional laboratory (anaerobic threshold) and field tests (shuttle run) were also performed.

Figure 1. *Methodological procedures*

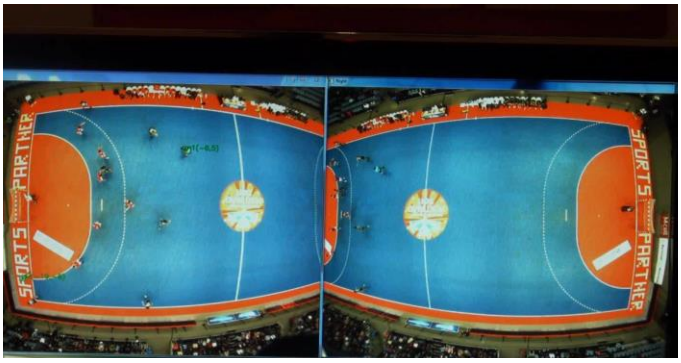

Figure 2. *Aerial perspective from two overhead mounted cameras*

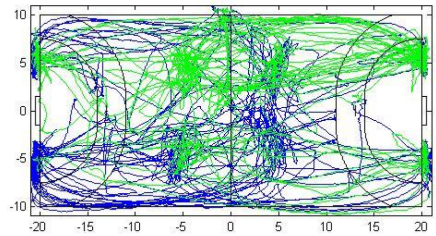

Figure 3. *Displacement maps (referees) - 30 minutes of a match – first half*

Development (results and discussion)

The obtained location data was differentiated and the displacement velocities of referees were then computed. In Figure 4 the average velocity distribution is presented. On average the referees covered 6.2 (±0.3) km per match at an average velocity of 5km/h, what is similar to other published results. Most of the time (60%) they were standing still or walking and during 7% of the time they were running between 9 km/h and 15km/h (Figure 5 and Figure 6). The detailed time pattern shows that, on average, the game pattern imposes 120 *defense-attack* transitions per match, with 10s per defense-attack transition (referees do 25m excursion at about 9km/h) and 20s per attack phase (were the referees are most of the time at a constant position).

We also observed that the bioenergetic demand of these matches is modest (900kcal/h to 1100 kcal/h per match). Similar findings were provided by other authors (da Silva, et al., 2010).

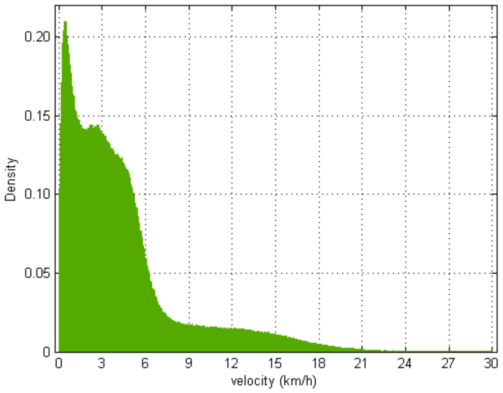

Figure 4. *Average velocity distribution*

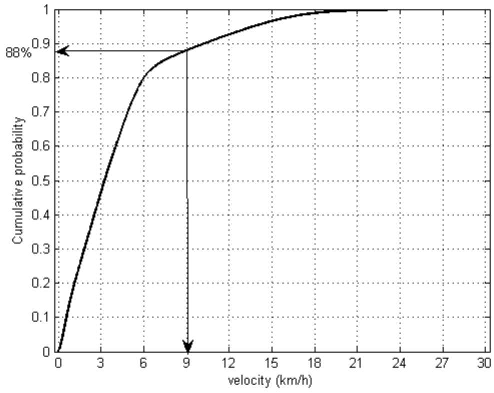

Figure 5. *Cumulative velocity distribution*

A comparison between the usual exertion metrics (heart rate, accelerometry) and the effective velocity show that the formers are very bad exertion indicators (Kendall tau=0.38). During 46% of the match the heart rate is above the anaerobic threshold while the real exertion is, during 88% of the time, well below that (Figure 6). As mentioned the referees were also submitted to additional laboratory tests (lactate based anaerobic threshold, $\dot{V}$O2max) after the tournament. These were combined with sleep and daily life monitoring data as well as in-field results (heart rate and physical exertion) to show the importance of stress in the heart rate response even in the nights before the big matches.

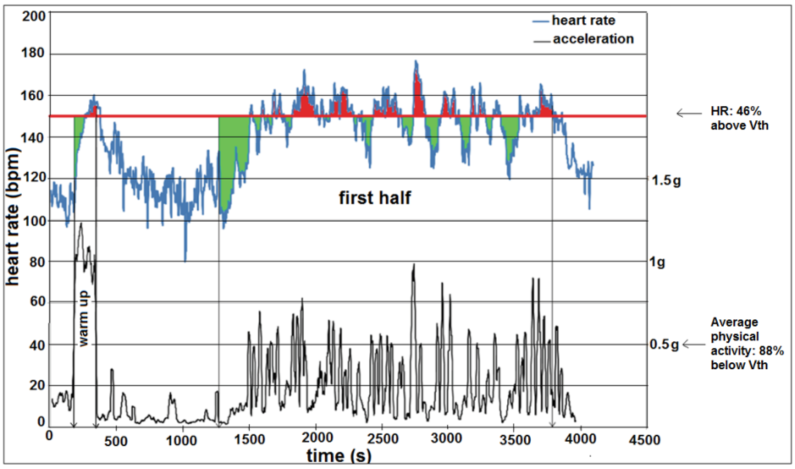

Figure 6. *Relationship between heart rate response and physical exertion.*

Conclusions

The results show a tri-modal modal velocity distribution with peaks around 0 km/h (stand still), 4.5 km/h (walk) and 13 km/h (run). Average displacement is 6 km, in accordance with other published results. We also concluded that the bioenergetics demands of the Portuguese high level matches are modest.

Finally, these results were commissioned by the Portuguese Handball Federation and have been used to develop and propose conditional evaluation procedures and training programs for the Portuguese elite referees. The results emphasize the need for a long term strategy to deal with high levels of stress in referees.

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EFFECT OF A SHORT TERM IN-SEASON MUSCULAR STRENGTH TRAINING PROGRAM WITH HALF BACK SQUAT ON REPEATED SPRINT ABILITY AND AGILITY T-HALF TEST PERFORMANCE IN ELITE HANDBALL PLAYERS

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Abstract
The evidence exists that during recent years handball has become more physically demanding, and that short-term muscle power has become crucial in many decisive game situations. We aimed to investigate the effect of a 6-week explosive muscular strength training program of lower limb in elite junior handball players. The maximal squat strength did not imply reduced maximal repeated sprint and agility performance in high level handball players.

Keywords
handball, muscular leg strength, RSA, agility test

Introduction

In many situations, to score goals or to stop goals being scored, the player should be faster and more powerful than the opponent. Moreover, by increasing force in appropriate muscles or muscles groups, acceleration and speed may improve in skills critical to handball such as turning, sprinting, and changing pace (Hermassi et al. 2011a ; Massuça et al. 2013). Handball is becoming more and more athletic and to win a running or jumping duel or to catch the ball before the opponent and to score, high short-term muscle power is necessary. The power produced depends on both force and velocity.

In fact, the physiological adaptations to resistance training depend on the type of contraction, duration, and intensity used during the program. There are several types of strength training, including isometrics, dynamic constant external resistance training, plyometrics, or isokinetics (Hermassi et al. 2011a ; Krüger et al. 2013). The most important variable in increasing strength is the load applied to the muscles. However, velocity-specific training has also been shown to maximize strength and power gains for athletes (Hermassi et al. 2011a). Resistance training has the potential of improving sport performances and reducing the rate of sport injury and rehabilitation time following injury (Massuça et al. 2013).

We hypothesized that a dynamic program with relatively high loads performed twice a week and over 6 weeks could enhance repeated sprint ability and agility T-half test performance in elite handball players. The aim of the present study was therefore to assess the effects of a 6 weeks resistance training program on a variety of performance tasks in this age group.

Methods

Participants

Twenty two junior handball players (age: 20.0.3 ± 0.4 years; body mass: 96.1 ± 8.2 kg; height: 1.90 ± 0.32 m; percentage body fat: 12.9 ± 3.1 %; handball experience: 9.1 ± 0.3 years), were recruited from a single national-level team, under conditions approved by the Institutional Review Committee for the ethical use of human subjects, in accordance with current national and international laws and regulations. Subjects gave their written informed consent to participation in the study, after receiving both a verbal and a written explanation of the experimental design and its potential risks.

Testing

1-RM Back Half Squat at 90° Degrees. Each participant kept an upright position, looking forward and firmly grasping the bar with both hands. The bar was also supported on the shoulders. Then the subject bent his knees until he reached the limit of 90 degrees. After that the subject raised himself to the upright position with the lower limbs completely extended. Because this technique was unfamiliar for the participants in this study, an instructor explained and demonstrated this lifting technique. All subjects performed 8 technical training sessions during the month preceding the 1-RM measurements. During the familiarization session, a pretest RM was done to determine the approximate RM value. To measure the experimental RM values, a barbell was loaded with free weights across the upper back of the participant and using an initial loading corresponding to 90% of the pre-test RM. Two consecutive loaded flexion–extensions were performed at 90 degrees of knee flexion (a back half squat). Each time the 2 repetitions were mastered, a load of 5 kg was added after allowing a recovery interval of at least 5 minutes. When the subject performed 2 successful repetitions with his pre-test RM value, a load of 1 kg was added after the recovery period. If the individual was unable to successfully complete the second repetition with the new loading, the corresponding load was considered as the individual's 1-RM. The average number of lifting actions before reaching 1-RM was 3 to 6.

Agility T-test

The agility T-test was performed using the same directives protocol of the T-test, except that the total distance covered and measures of intercone distance were modified. The number of directional changes were maintained the same. Subjects covered a total distance of 20 m on the modified T-test instead of 36.56 m on the T-test. Criteria for accepted test trials were the same of those used on the T-test. The recorded score for this test was the better of two last trials (test–retest session) (Hermassi et al. 2011b).

Repeated-shuttle sprint ability test

The RSA test involved six repetitions of 30 m (2 × 15 m) shuttle sprints (taking approximately 6 s to finish) departing every 20 s, which is a modification of the protocol used by Buchheit et al (2008) and Bishop et al (2004). During the approximately 14 s recovery between sprints, subjects were required to perform an active recovery (brisk walk back to the starting line). Two seconds before starting each sprint, the subjects were asked to take the start position as detailed for the 15 m sprints and await the start signal from a pre-recorded sound track. This test was adapted from a previous running test that has been shown to produce reliable and valid estimates of RSA (Bishop et al. 2004). Three scores were calculated for the RSA test: the best sprint time (RSA_{best}), usually the first sprint; the total sprint time (RSA_{TT}) and the percentage of sprint decrement (RSA_{dec}) calculated was as follow (Buchheit et al. 2008): 100 – (mean time / best time × 100).

Training Program.

The resistance training program for the experimental group (Gex) was carried out twice a week, immediately before the regular handball training session. The strength training sessions were performed on Tuesday and Thursday. Back half squat was used as a training exercise. The loads were calculated using the individual 1-RM previously measured. This 1-RM value was reassessed at the fourth week and the strength loads used for training sessions were updated. The strength training session consisted of 7 repetitions at 70%RM, 4 repetitions at 80% RM, 3 repetitions at 85% RM, and 2 repetitions at 90%RM. The load of 70% is considered as a warm-up exercise. The aim of the resistance training program was to obtain an optimal increase in muscle strength followed by a delayed increase in muscle power. For review, see Blimkie and Sale (1998). The training protocol used in this study was based on the 1-RM performance of each individual. It is well known that motivation of the individual plays an important role in muscle strength improvement. Verbal encouragements were constantly given to maintain high motivation in this particular group of soccer players. Furthermore, familiarization training sessions were carried out to obtain ‘‘true’’ RM measurements.

Results

The Gex showed a significant increase in strenght muscle for comparison (table 1). The Gex showed gains relative to controls in 1-RM muscular strength of half back squat ($p<0.05$), RSA_{best} ($p < 0.01$), RSA_{TT} ($p <0.01$), RSA_{Dec} ($p < 0.001$), (Figure 1) and agility T-half test performance ($p < 0.001$; Figure 2).

Table 1. *Repeated-sprint ability and jump test before and after plyometric training.*

	Test	Gex (n=12)	CG (n=10)
Maximal squat strength 1-RM			
	Pre	201± 3.1	198± 3.1
	Post	232± 5.3**	199± 7.2
Repeated-sprint ability			
RSA_{best}	Pre	6.1 ± 0.2	6.3 ± 0.4
	Post	5.9 ± 0.1**	6.2 ± 0.3
RSA_{TT}	Pre	37.65± 0.3	37.60 ± 0.1
	Post	36.01 ± 0.1**	37.55 ± 0.2
RSA_{dec}	Pre	4 ± 0.2	4.28 ± 0.4
	Post	3.7 ±0.2***	4.37 ± 0.3
Agility T-half test			
	Pre	8.83 ± 2.1	8.91 ± 0.2
	Post	8.01 ± 1.3**	8.87 ± 0.1

*Gex = plyometric training group; CG = control group. **p < 0.01 ; ***p < 0.001.*

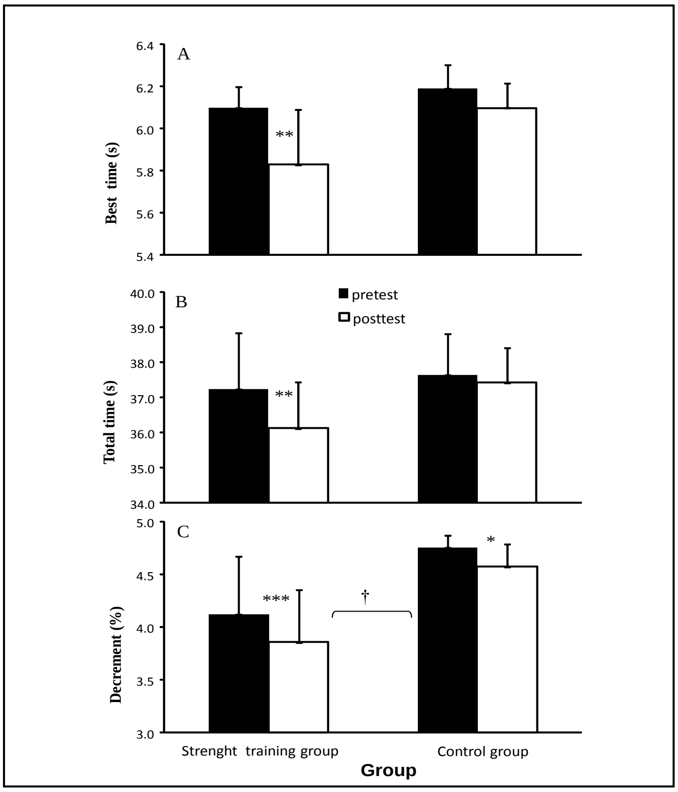

Figure 1. *A) Fastest sprint time, B) total sprint time and C) percentage of decrement in sprint time (Mean ± SD) at pre- and post test for strength and control group. (*) indicates significant main effect from pre- to post test for this group (p<0.05). † indicates significant difference between the groups at the pre-and post test on a p ≤ 0.05 level.*

Discussion

The primary aims of this study were to determine whether junior male handball players could enhance muscle strength by an in-season short-term resistance training program for the lower limbs, and whether gains could be realized without detriment to other aspects of performance. To the best of our knowledge this is the first study to examine gains of on leg strength, repeated shuttle-sprint ability, and agility performance in top junior's handball players, the results indicated that 6 weeks of muscular strength of half back squat within handball practice induced positive effects on explosive actions of our handball players.

Maximal Leg Strength

The 1-RM muscular strength of half back squat remained statistically comparable between the experimental and the control groups (Table 1). Whether resistance training induced changes in limb morphology in juniors palyers is still a matter of debate. Therefore, it has been suggested that the increase of leg strength muscle is essentially a result of neuronal adaptations and coordination (Schmidtbleicher, 1992; Behm, 1993). In fact, neuronal adaptations include many factors, such as selective activation of motors units, synchronization, selective activation of muscles, and increased recruitment of motor units (Behm et al. 1993). The use of high loads (60–80% of 1-RM) with rapid actions to cause a maximal neural adaptation. The use of explosive movements with heavy loads (80 of 1-RM) and few repetitions (3–4) (Schmidtbleicher, 1992) to stimulate neuronal adaptations that are in accordance with the strength training program used in the present study. In juniors players, the twitch interpolation technique (Ramsay et al. 1990) has been used to assess the contribution of changes in motor unit activation to training-induced strength increases (Ramsay et al. 1990). Training experience, therefore, may have an impact on the responses to training in male athletes. Moreover, muscle fiber size and morphological characteristics, which are closely related to force generation, increase and have a tendency to plateau at the age of 18 to 19 years (Van Praagh et al. 2002).

Reaped Sprint Ability Test:

Acceleration, rapid changes in direction and agility are inherent to both practice and competition in handball (Buchheit et al. 2010; Hermassi et al. 2011a). Such efforts depend not only on maximal strength, but also on muscle power. Our investigation showed improved reaped sprint performance after resistance training program in all measured and calculated velocities (figure 1). Maximal intensity shuttle sprinting necessitates extremely high levels of neuronal activation (Buchheit et al. 2010; Hermassi et al. 2011a). Potential mechanisms for improvements in sprint performance include changes in temporal sequencing of muscle activation for more efficient movement, preferential recruitment of the fastest motor units, increased nerve conduction velocity, frequency or degree of muscle innervations, and increased ability to maintain muscle recruitment and rapid firing throughout the sprint (Mero, 1998; Edge et al; 2005). Given the great importance of changing direction while sprinting at near maximal repeated speeds in handball (Mero, 1998; Buchheit et al. 2010; Edge et al. 2005), the present data suggest that these resistance training should be part of the training program in juniors handball players'.

Agility T-half Test

In the present study, resistance training programs of 6-week durations, equalized for training volume, resulted in significant improvements in agility performance. During a strength movement, the muscles undergo a very rapid switch from the eccentric to the concentric phase. This stretch-shortening cycle decreases the time of the amortization phase that in turn allows for greater than normal power production (Hermassi et al. 2011). The muscles stored elastic energy and stretch reflex response are essentially exploited in this manner, permitting more work to be done by the muscle during the concentric phase of movement (Hermassi et al. 2011b). Training programs that have utilized specific exercises have been shown to positively affect performance in power-related movements such as change direction. The use of strength training has been advocated for several years as a means of improving performance in sports and activities in which lower-body power plays a key role in success.

This study shows that elite junior handball players can enhance muscle strength by undertaking a 6-week biweekly in season program of resistance training involving exercises for lower limbs.

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RELATIONSHIPS BETWEEN MEDICINE BALL EXPLOSIVE POWER TEST, THROWING BALL VELOCITY AND MAXIMAL ARM STRENGTH IN TEAM HANDBALL PLAYERS

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Abstract
The success of a shot in a game of team handball very often depends on the throwing velocity. Therefore, this study aimed to investigate relationships between medicine ball explosive power tests, maximal arm strength and handball throwing velocity in elite team handball players.

Keywords
handball, maximal repetition tests, testing, throwing performance.

Introduction
In team handball, the ability to score a goal depend on the velocity of the ball and the accuracy of the throw (Gorostiaga et al. 2005; van den Tillar et al. 2010). To our knowledge, few studies have examined the relationship between ball throwing performance in elite team-handball players and indices of dynamic strength (Gorostiaga et al. 2005), power, (Chelly al. 2010) and bar velocity (Marques et al. 2007) during muscle contractions of the upper extremity. Other investigations have used isokinetic and isometric tests as indices of strength (Fleck et al. 1992; van den Tillar et al. 2003).

The use of medicine balls in sports training is growing as practitioners see the wide range of skills that can be trained or simulated (Barry, 2001).. In an attempt to make training programs more sport specific, strength and conditioning coaches are continuously exploring new ways of using medicine balls to train the specific physiologic or biomechanical variables required for success in their particular sport. Therefore, this study aimed to investigate relationships between medicine ball explosive power tests, maximal arm strength and handball throwing velocity in elite team handball players.

Methods
Participants
Fourty one elite male handball players (U16, n = 20: age: 15 .9 ± 0.2 years; body mass: 71.1 ± 8.1 kg; height: 1.79 ± 0.22 m and U18, n = 21: age: 17 .8 ± 0.3 years; body mass: 82.4 ± 7.1 kg; height: 1.85 ± 0.36) were recruited from a single national-level teams. Under conditions approved by the Institutional Review Committee for the ethical use of human subjects, in accordance with current national and international laws and regulations. Subjects gave their written informed consent to participation in the study, after receiving both a verbal and a written explanation of the experimental design and its potential risks.

Measures
Medicine ball explosive test. The standing backward overhead medicine ball throw consisted of starting with the feet shoulder width apart, heels on the zero measurement line, and the medicine ball held with arms straight out front at shoulder height. The countermovement consisted of the subjects flexing the hips and knees. At the same time, they also flexed

forward at the trunk, lowering the medicine ball to just below waist or hip height. After the countermovement, the subjects began to thrust the hips forward and to extend the knees and trunk. They flexed the shoulders, elevating the ball back up to shoulder height and beyond as they threw it back over their head. The arms were maintained in an extended manner. The finishing point was with the ankles plantar flexed; the knees, hips, and trunk extended; and the shoulders flexed to above the head. During the countermovement, the subjects were asked not to bend the knees or hips any more than they normally would for a standard countermovement vertical jump. The shoulders maintained at least of shoulder flexion in relation to the trunk. At the end of the throw, the subjects' feet were allowed to leave the ground, as would happen with a jumping motion, to minimize any deceleration component of the vertical ground reaction forces. The subjects were also asked to keep their arms as straight as possible as they threw the ball back over their head with a pendulum action. This instruction was meant to force the legs, trunk, and shoulders to generate the power, as would be the case in a vertical jump (Barry, 2001).

Handball Throwing. Specific explosive strength was evaluated by making 3 types of overarm throw on an indoor handball court: a standing position (penalty) throw), 3-step running throw (RT) and a jump shot (JS). The standing and 3-step throws have been described by Hermassi et al. (2011). In the jump shot, players made a preparatory 3 step run before jumping vertically and releasing the ball while in the air, behind a line 9 m from the goal. Throwing times were recorded by digital video camera (Sony Handycam DCR-PC105^E, Tokyo, Japan), positioned on a tripod 3 m above and parallel to the player. Data processing software (Regavi and Regressi, Micrelec) converted measures of ball displacement to velocities. Throws with the greatest starting velocity were selected for further analysis. The reliability of the data processing software has been verified previously (Fathloun et al. 2011); measurements were accurate to 0.001 seconds, and the test–retest coefficient of variations in throwing velocity was 1.9%.

One Repetition maximum Pull-Over. The bar was positioned 0.2 m above the subject's chest and was supported by the bottom stops of the device. The player performed successive eccentric–concentric contractions from the starting position. A full description of the pull-over exercise used in this investigation is provided by Chelly et al. (2010). All subjects were familiar with the required technique, having used it in their weekly training sessions. A pretest assessment of 1-RM_{PO} was made during the final standard training session. For 1-RM_{PO}, warm-up for the definitive test comprised 5 repetitions at loads of 40–60% of the pretest 1-RM_{PO}. Thereafter, 4-5 separate attempts were performed until the subject was unable to extend the arms fully on 2 occasions. The load noted at the last acceptable extension was considered as the $1RM_{PO}$. Two minutes of rest was allowed between trials.

Statistical analysis

Findings are reported as means ± standard deviations (SD). Pearson's product moment correlations and linear regression analyses were used to examine relationships between medicine ball explosive power tests, throwing tests and maximal arm strength. Significance was assumed at 5% ($p \leq 0.05$). All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) (version 19.0 software for windows).

Results

The mean (±SD) for SP, RT, JS and 1-RM_{PO}; were 18.49 ± 2.52 $m \cdot s^{-1}$, 33.28 ± 3.47 $m \cdot s^{-1}$, 27.91 ± 0.97 $m \cdot s^{-1}$ and 48.40 ± 10.90 kg , respectively. The medicine ball explosive power tests was closely related to RT (r = 0.70, $p<0.01$). Significant relationships were observed between medicine ball to TR and SP (r = 0.73, p<0.05; r = 0.71, p<0.01 respectively). The medicine ball explosive power tests is also positively related to 1-RM_{PO} (r = 0.60, p < 0.01).

Table 1. Results of throwing velocity measurement and medicine ball explosive power test.

	Mean ± SD
Throwing handball velocity (m/s)	
Standing position throw (SP)	18.49 ± 2.52
3-step running throw (RT)	33.28 ± 3.47
Jump shot (JS)	27.91 ± 0.97
Maximal arm strength	
1-RM pull-over (kg)	48.40 ± 10.90

Table 2. Coefficients of correlation between measures of throwing velocity and medicine ball explosive power test.

	Medicine ball power tests (m/s)
Throwing handball velocity (m/s)	
Standing position throw (SP)	0.73 **
3-step running throw (RT)	0.70**
Jump shot (JS)	0.71**
Maximal arm strength	
1-RM pull-over (kg)	0.60**

*: p<0.05; ** : p<0.01

Discussion

The relationship between medicine ball explosive power tests and ball velocity was, in general, statistically significant for all speeds of throw, types of throw and groups tested. The main finding in our study was that in three types of throw with various throwing technique, and medicine ball explosive power tests was related to ball velocity.

When comparing our findings with the results of Fleck et al. (1992) study conducted in handball players of the U.S. National Team, we observe both agreements and disagreements. Fleck et al. (1992) did not find a significant relationship between the ball velocity in set shot and shoulder rotation at any of the isokinetic speeds studied (180, 240 and 300 deg/sec), which is in agreement with our results regarding the shot on the spot (same as set shot). However, they found a significant correlation between concentric rotation and jump shot at all speed tested. These results seem in accordance with our present study; we found a correlation of 0.69 between explosive medicine ball test and RT (Table 2). Furthermore, the mass of upper limb muscle that contributes to handball throwing is small, and it may not correlate closely with the range of muscles solicited during upper limb exercise. Upper limb cranking is an activity with several degrees of freedom, and indeed the active muscle is likely to be substantially greater than that estimated by our approach; in particular, our mesure do not include the shoulder muscles.

Several recent studies of elite male handball players (Gorostiaga et al. 2005 ; Marques et al. 2007; Hermassi et al. 2011; van den Tillar et al. 2003) investigated the relationships of throwing velocity to bar velocity and bar power during bench press or half squat. Gorostiaga et al. (2005) reported a close relationship between 3-step running velocity and the bar velocity at 30% of 1-RM bench press (r = 0.72, p<0.01), with a moderate relationship to power at 100% of body mass in the half squat exercise (r = 0.62, p<0.05). A close relationship between standing throwing velocity and 1-RM bench press (r = 0.80, p<0.001) was also reported (Marques et al. 2007). van den Tillaar and Ettema (2004) reported a weak correlation between isometric handgrip strength and ball-throwing velocity for female team handball players (r = 0.49), as well as for male team-handball players (r = 0.43). Hoff and Almasbakk (2004) observed a greater association between ball-throwing velocity and 1-RM pench press (r = 0.88) in female team-handball players, suggesting that dynamic, multijoint tests might prove more useful than isometric or single-joint assessments.

Nevertheless, it is difficult to compare these results with our findings, because of differences in methodology and the type of tests that was used. The studies cited used a rotary encoder linked to the end of the bar to record bar displacement, average velocity and average power of the bar. Moreover all of these parameters were only assessed during a concentric bench press exercise. In our investigation, we measured explosive strenght as dependent variables. In addition, we adopted a simultaneous eccentric-concentric upper limb muscle contraction with medicine ball throw.

Our results also highlight the contribution of the upper limbs to handball throwing velocity, suggesting the need for coaches to include upper and lower limb strength and power programs when improving the throwing velocity of handball players.

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RELATIONSHIP BETWEEN YO YO INTERMITTENT RECOVERY TEST PERFORMANCE AND SELECTED PHYSICAL ABILITIES IN ELITE JUNIORS HANDBALL PLAYERS

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Abstract
Handball play is characterized by repeated bursts of intense anaerobic activity, and it is thus logical to evaluate overall ability in terms of the individual's tolerance of repeated bouts of intensive exercise. The aim was to investigate the relationships between Yo-Yo test performance and the peak power of the lower limbs, jumping and agility T-half test. It was shown that the Yoyo IR 1 test had moderate to strong correlations with the other selected physical abilities and thereby showed to be a good overall test in handball

Keywords
muscular leg power, jumping performance, force–velocity test, agility test.

Introduction

Handball play is characterized by repeated bursts of intense anaerobic activity (Kruger et al., 2013; Manchado et al., 2013). Therefore it is logical to evaluate overall ability in terms of the individual's tolerance of repeated bouts of intensive exercise. The Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1), as proposed by Bangsbo (1991), seems an appropriate test for this purpose. It requires repeated bouts of effort at progressively increasing velocities, interspersed with 10-seconds intervals of active recovery, with the test continued to exhaustion. The test has been validated both externally and internally (Souhail et al., 2010; Bangsbo et al., 2008; Krustrup et al., 2003).

TheYo-Yo IR1 was designed to evaluate the intermittent-endurance ability of participants in team sports, and it has achieved much popularity in both research and practical settings (Bangsbo et al., 2008; Buchheit & Rabbani, 2013). It has proven to be a reliable and valid measurement of match-related fitness in youth handball players (Souhail et al., 2010). Furthermore it demonstrated capability to distinguish player performances at various levels of competition, in diverse playing positions and after varying periods of training (Bangsbo et al., 2008).

However, information about the sensitivity of the Yo-Yo IR1 test and its relationship to other commonly used measures of athletic performance remains quite limited. Heart rates have been measured during testing (Souhail et al., 2010; Krustrup et al., 2003; Rampinini et al., 2010), but relationships with other measures of anaerobic performance have yet to be examined. Therefore the aim of the present study is to investigate the eventual relationships between Yo-Yo test performance and the peak power of the lower limbs, jumping and agility T-half test. We hypothesized that the Yo-Yo IR1 test would provide a simple inclusive index of a person's capacity for handball play, indicating not only aerobic qualities and the ability to recover between exercise bouts, but also the strength and maximal explosive power of the lower limbs.

Methods

Participants

Twenty four juniors handball players (age: 18 .9 ± 0.4 years; body mass: 92.2 ± 10.3 kg; height: 1.91 ± 0.52 m; percentage body fat: 13.8 ± 2.3 %; handball experience: 9.1 ± 0.3 years) were recruited from a single national-level team, under conditions approved by the Institutional Review Committee for the ethical use of human subjects, in accordance with current national and international laws and regulations. Subjects gave their written informed consent to participation in the study, after receiving both a verbal and a written explanation of the experimental design and its potential risks.

Measures

Yo-Yo Intermittent Recovery test Level 1 (Yo-Yo IR1):

The Yo-Yo IR1 was performed according to the procedures suggested by Krustrup (2003). The test consists of repeated 2 x 20 m runs back and forth between the starting, turning, and finishing line at a progressively increasing speed controlled by an audio metronome from a calibrated CD player. The participants had a 10 sec active rest period (decelerating and walking back to the starting line) between each running bout. When a participant failed twice to reach the finishing line in time, or decided that he could no longer run at the imposed pace, the total distance covered was recorded. The reliability of Yo-Yo IR1 was established in a previous study (Krustrup et al., 2003).

Force–velocity test:

A Force-velocity test was performed on a standard Monark cycle ergometer (model 894 [E], Monark Exercise AB, Vansbro, Sweden), as detailed elsewhere (Chelly et al., 2010; Hermassi et al. 2011a). In brief, the maximal pedalling velocity attained during a 7 second all-out sprint was used to calculate the maximal anaerobic power for each braking force, and the subject was judged to have reached leg peak power (Wpeak) if a further increase of loading induced a decrease in power output.

Squat Jump (SJ) and Countermovement Jump (CMJ)

Characteristics of the SJ and the CMJ were determined using a force platform (Quattro Jump, version 1.04; Kistler Instrumente AG, Winterthur, Switzerland). Jump height was determined as the centre of mass displacement, calculated from the recorded force and body mass. Subjects were instructed to keep their legs straight throughout the flight phase. The SJ began at 90° knee flexion; a vertical jump was performed by pushing upward with the legs, avoiding any downward movement. The CMJ began from an upright position; subjects made a downward movement to 90° knee flexion and simultaneously began the push-off phase. The best of 3 jumps was recorded for each test.

Agility T-test

The agility T-test was performed using the same directives protocol of the T-test, except that the total distance covered and measures of inter-cone distance were modified. The number of directional changes were maintained the same. Subjects covered a total distance of 20 m on the modified T-test instead of 36.56 m on the T-test. Criteria for accepted test trials were the same of those used on the T-test. The fastest time of the two trials was taken for further analysis (Hermassi et al. 2011b).

Statistical Analysis

Findings are reported as means ± standard deviations (SD). Pearson's product moment correlations and linear regression analyses were used to examine relationships between the Yo-Yo IR1 test performance and other measures of physical ability. Significance was assumed at 5% ($p \leq 0.05$). All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) (version 19.0 software for windows).

Results

The performance of all tests (i.e., Yo Yo IR1, Wpeak, SJ, CMJ and agility T-half test) are summarized in Table 1. The YoYo IR1 total distance covered (DC) and maximal aerobic speed (MAS) were positively associated with the absolute Wpeak for the lower limbs (r = 0.79 and r = 0.80 respectively; p< 0.01; Figure 1 and Table 2). Significant correlations were also found between DC and MAS and CMJ and SJ (r = 0.62 and r = 0.65 respectively; p < 0.01; Figure 2 and Table 2). There was a moderate correlation between DC and MAS and the agility T-half test (r = 0.66; r = 0.64 respectively p< 0.01 Figure 2 and Table 2). The MAS of IR1 test score were also found to have a moderate to large association with other explosive power measurements in elite handball players (Table 2).

Table 1. *Mean ± SD of the parameters measured.*

Test	Mean ± SD (n=24)
Yo-Yo Intermittent recovery test	
The maximal aerobic speed (MAS) (m/s)	4.8± 0.3
Total distance covered (DC) (m)	1772 ± 343
Force-velocity test	
Peak power (W)	920.98 ± 105
Peak power (W/kg)	12.7 ± 2.3
Jump test	
Squat jump height (cm)	40. 58 ± 2.5
Countermovement jump height (cm)	44.30 ± 1.9
Agility T-half test	10.28 ± 0.88

Table 2. *Correlations between the performance indices (MAS, DC) of the Yo-Yo IR1 test and other test parameters (n=24).*

	Parameter	(MAS)	(DC)
Force-velocity test	Peak power (W)	0.80***	0.79**
	Peak power (W/kg)	0.65**	0.68**
Jump test	Squat jump height (m)	0.66**	0.69**
	Counter movement jump height (m)	0.62**	0.59**
Agility T-half test		0.66**	0.64**

*** Significant correlation at p<0.01 level; ** Significant correlation at p<0.05 level;

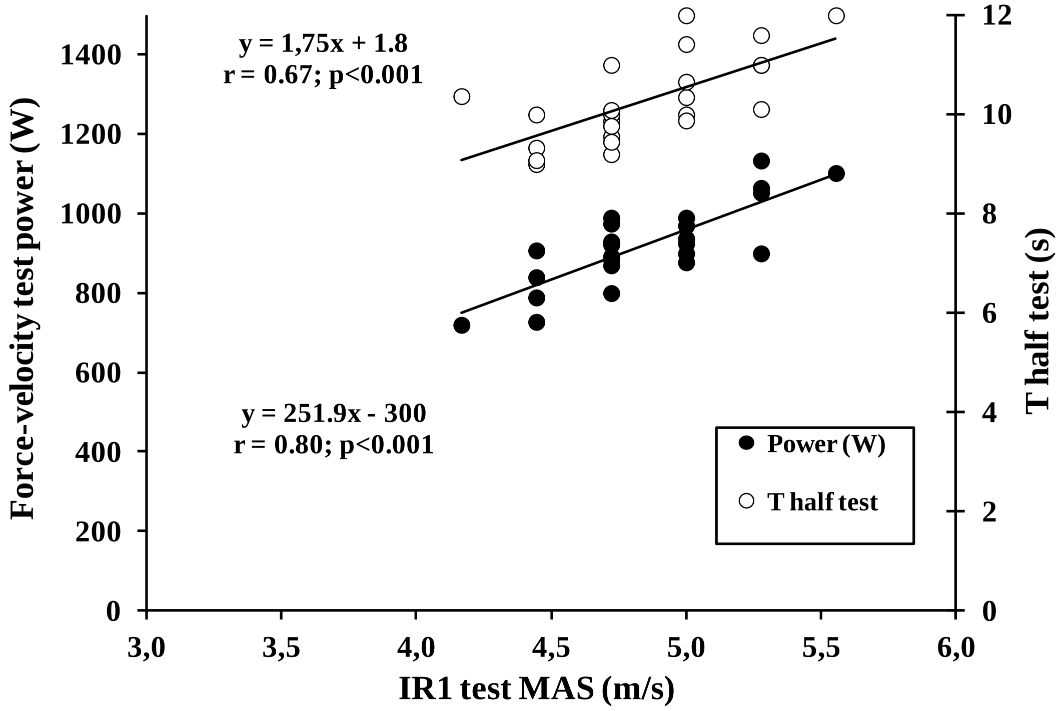

Figure 1. *Relationships between aerobic speed reached in the Yo-Yo IR1 and both leg peak power and Agility T-half test performance.*

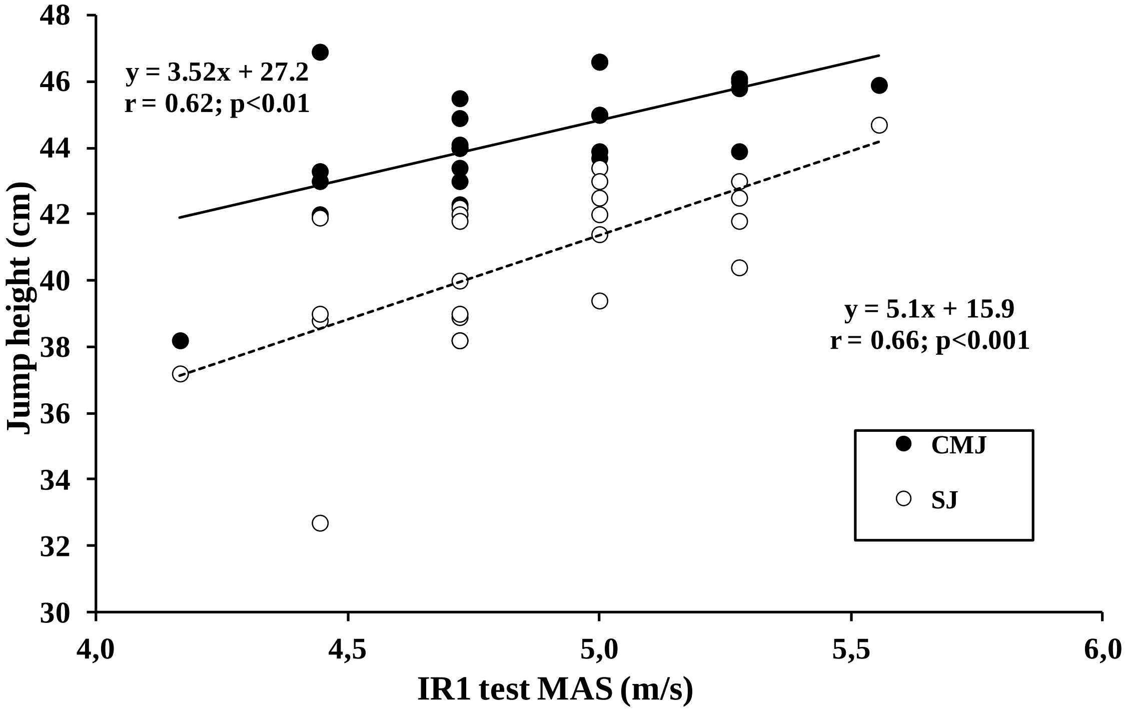

Figure 2. *Relationships between between aerobic speed reached in the Yo-Yo IR1 and both jump height: Counter Movement Jump and Squat Jump (CMJ and SJ respectively).*

Discussion

In accordance with our hypothesis, the main finding from our study is that performance of the Yo-Yo IR1 test does provide an overall assessment of the handball player: the maximal intermittent running velocity on this test shows significant associations with scores for several other tests used to assess explosive force and agility performance in this sport.

Normally handball players are more familiar with running than with cycling, and lower limb cranking is essentially a cyclic movement, whereas sprinting reflects power obtained from a single whole-body movement (Wadley & Le Rossignol, 1993; Wragg et al., 2000). Despite the difference in test modality, substantial correlations were seen between the MAS and the peak power output in our 7s maximum cycle ergometry test. Possibly, our cycle ergometer protocol approximates more closely to muscle contraction dynamics and contraction times associated with the sprinting tests. The High levels of neural activation are needed to reach maximal sprint velocities. Potential mechanisms developing sprint performance in the handball player include more efficient movement due to changes in temporal sequencing of muscle activation, preferential recruitment of fast motor units and increased nerve conduction velocity (Wragg et al., 2000).

Competitive handball play requires frequent turning and changes of directions at a variety of intensities (Hermassi et al., 2011a), demanding both muscular power and strength. The vertical jump performance of handball players depends on their competitive level (Hermassi et al., 2011a; Gorostiaga et al., 2006), showing that this field test provides a useful measure of ability. As expected IR1 MAS and jump performances related positively with each other probably due to their similarity in muscle contraction (stretch shortening cycle); many other results in the scientific literature show moderately close relationships between sprint and jumping performance. Castagna et al (2006) also found a significant correlation between the MAS and vertical jump performance.

Maximizing of velocity over the agility displacement is a complex motor task, characterized by the ability to develop large forces in the horizontal plane over a short time period and the change of direction (Hafez et al., 1988). The relationship of the performance indices of the IR1 to the agility T-half test has not been investigated previously. The existence of strong relationships is at first inspection somewhat surprising, since the two tests were intended to measure apparently differing abilities. However, the Yo-Yo IR1 test requires a sprint start with each change of direction, which could partially explain the observed relationship. The moderate relationship between the MAS, DC and the agility T-half test is likewise somewhat surprising, since the items purportedly measured are endurance vs. agility and speed. As the agility test is essentially based upon accelerating forwards or backwards, with the subject exerting explosive force at each change of direction. However, in actual play, open skills are required, as players anticipate, make decisions, solve problems and evaluate in a constantly changing environment (Schmidt et al., 2000).

The present results, obtained on top-level handball players, suggest that the performance of a single field test, the MAS on the Yo-Yo IR1 test, provides information that is strongly correlated with the results obtained from a series of field performance tests for team athletes, . It requires a minimum of equipment, and may thus prove an effective measure of the response of individual players to both training and rehabilitation.

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DESIGN AND VALIDITY OF SPECIFIC HANDBALL REPEATED SPRINT ABILITY TEST

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Summary
Background: Tests of repeated-sprint ability are becoming popular as a way of evaluating performance capabilities in field and court sports.
Objective: The aim of this study was to create the design of specific handball repeated-sprint ability test indicating the agility and repeated-sprint ability, and verify its validity.
Methods: Twenty women handball players participating in two highest Czech leagues (age = 20.78 ± 1.32 years) and ten well trained female university students of physical education (age = 21.34 ± 1.13 years) underwent the 10x 54.5 m specific handball repeated-sprint ability test with 24 s recovery. The index of agility (average of three best sprints), Total time and Sprint decrement were observed. The one-way ANOVA and Fisher LSD post-hoc test were used to determine the criterial validity.
Results: We determined significant differences in total time and the index of agility, the results showed significantly lower performance of the group of athletes compared with handball players. As it is the group of the second Czech league, handball players reach significantly lower performance than the group of the highest Czech handball league. We did not find any significant differences in sprint decrement.
Conclusions: We found out that the specific handball repeated-sprint ability test is a valid indicator of specific handball agility expressed by the index of agility and repeated-sprint ability expressed by total time. Sprint decrement seems not to be valid for the repeated-sprint ability indicator in handball.

Keywords
intermittent exercise, Sprint decrement, specificity, recovery

Introduction

Contemporary training process underwent a lot of shifts based on increasing scientific and expert knowledge about the nature of conditioning in team games like basketball and handball. The specificity of metabolic training becomes to be the key factor of the planning the training process because of attaining specific physiological adaptations as much as possible. That is why we should analyse the demands of the game by time motion analysis (Reilly, 2005) and adequately operate with player's load intensity and activities during the training process.

Time motion analysis research indicates that handball is a high speed an intermittent game similarly to other sport games (Kotzamanidis, Chatzikotoluas & Giannakos, 1999; Perš, Mart, Stanislav & Marko, 2002; Pori, et al., 2005). It means that it is characterised by irregular changes between high and low intensity activities over very short periods of time (up to 10 s) when low intensity activities are related to recovery processes (Balsom, Seger, Sjodin, & Ekblom, 1992).

The ability to quickly replenish energy stores during short and active rest in working muscles is critical for handball performance (Perš et al., 2002) which is called repeated-sprint ability - RSA (Girard, Mendez-Villanueva, & Bishop, 2011). RSA-based exercises are characterized by several sprints interspersed with brief recovery periods. Such exercise results in metabolic responses similar to those which occur during actual matches, such as decrease in muscle pH, phosphocreatine and ATP, activation of anaerobic glycolysis and significant involvement of aerobic metabolism (Rampinini et al., 2007; Wragg, Maxwell, & Doust, 2000). Therefore the use of RSA-based exercises for training and testing team sport athletes is increasing (Spencer, Bishop, Dawson, & Goodman, 2005).

The shift in thinking of conditioning had to bring the change in the means of performance testing to respect the specificities of the game demands. That is why the tests of multiple sprints performance or repeated-sprint ability are becoming increasingly popular as a way of evaluation of performance capabilities of athletes involved in field and court sports (Glaister et al., 2009).

We constructed the specific handball repeated ability test which tries to simulate game demands of handball game because no performance test is constructed to indicate repeated-sprint ability and use the agility parameters during the sprint activity as well as during the match of handball yet.

In addition, before using the new performance test effectively, the researchers should determine reliability of the measurement Spencer, Fitzsimons, Dawson, Bishop and Goodman (2006). We followed recommendations of Atkinson and Nevill (1998) and Hopkins, Schabort and Hawley (2001) for reliability measurement design and we used indicators of relative (intraclass correlation coefficient) and absolute reliability (coefficient of variation and Bland and Altman's 95% limits of agreement).

The aim of this study was to create the design of the specific handball repeated-sprint ability test indicating agility and repeated-sprint ability, and verify its validity.

Methods

Participants

Ten women handball players participating in the highest Czech league WHILL (age = 20.36 ± 1.05 years), ten women handball players participating in the second highest Czech league (age = 21.28 ± 1.82 years) and ten well trained female university students of Physical Education (age = 21.34 ± 1.13 years) underwent the 10x 54.5 m specific handball repeated-sprint ability test. The aims and objectives of the study were clarified to all participants and written informed consent was then signed. Participation was voluntary and players and students could withdraw from the study at any time.

Procedures

All participants were apprised of the protocol and they completed one pre-test trial. Next the participants completed the test again. These measurements were conducted one week apart always after one day off. The research was held after the regular season. The trials were performed at the same day-time to minimise the effect of diurnal variability. The subjects were instructed not to take any food two hours before testing. All measurements took place in a handball gym with standardized size of the court (40x20 m) with polyurethane (synthetic rubber) surface.

Specific repeated-sprint ability test protocol

Participants completed 15 minutes of active warm up before testing and thereafter five short sprints. Five minute recovery with test protocol description then followed. The participants completed 10 x 50 m sprint activities according to Fig. 1 with 24 s recovery. The work rest ratio was determined from results of time motion analysis (Chelly et al., 2011) to work/rest ratio = 1/2. The duration of the sprints separated by changes of direction was shorter than 2 s (average duration of the sprint during a match according to Chelly et al., 2011). Average sprint activity time was 12.31±0.88 s and adequately the rest was determined to 24 s. The scheme of the sprint should simulate the transition to the defence to goal-area line, attacking the offender on the free throw line and recovering to goal-area line, and transition to the fast break.

Three variables from the raw data were calculated. The first was *the first sprint time* (s) as an indicator of speed and agility, *sprint decrement* (%) and *total time* (s) as the indicators of repeated-sprint ability. Sprint decrement (S_{dec}) was calculated according to Girard et al. (2011):

$$S_{dec}(\%) = \left\{\frac{(S_1 + S_2 + \cdots + S_{10}}{10 * S_{best}} - 1\right\} * 100$$

where $S_{1\text{-}10}$ are times of ten single sprints, S_{best} is the best time of single sprints. Total time was calculated as the sum of ten single sprint times.

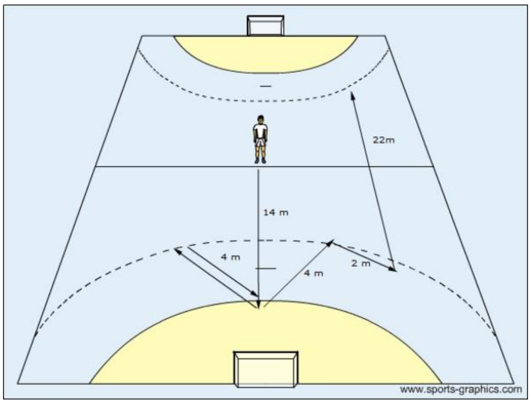

Figure 1. *The scheme of the RSA test*

Statistical analysis

Software SPSS 17 (SPSS Inc., Chicago, IL) and Statistica 10 (StatSoft Inc., Tulsa, OK) were used to process the data. Mean and standard deviation were calculated to describe participant's performance in the test. The one-way ANOVA and Fisher LSD post-hoc test were used to determine the criterial validity.

Results

The first sprint time of the group of WHILL players was 10.71±0.34 s, total time was 116.29±3.97 s, and Sprint decrement 8.62±2.90 %. The group of second highest league players attained the first sprint time 11.57±0.41 s, total time was 124.61±6.23 s, and Sprint decrement 7.71±2.95 %. Finally the group of well-trained female university students achieved the first sprint time 12.08±0.24 s, total time was 132.71±3.36 s, and Sprint decrement 9.90±1.32%.

We determined significant differences in total time (F=27.61; p=0.00) and index of agility (F=7.13; p=0.00), the results showed significantly lower performance of the group of athletes compared with handball players. The Fisher LSD post-hoc test confirmed statistical differences among all groups.

We did not find statistically significant differences (*F*=1.72; *p*=1.19) among the monitored groups in sprint decrement obtained by ANOVA (*F*=1.72; *p*=1.19) and the Fisher LSD post-hoc test.

Discussion

The aim of this study was to create the design of specific handball repeated-sprint ability test indicating agility and repeated-sprint ability, and verify its validity.

Many changes of speed, type of locomotion, direction and a lot of jumps which occur during the game require the emphasis on quickness and power development in training. Agility connected with strength and quickness is an essential part of skills in handball because they enable to perform players' activities during the game in necessary height, speed and at right moment (Gamble, 2010). The group of WHILL players performed the best results in the first sprint time as an indicator of speed and agility, the group of well-trained female university students of physical education was the worst one. We suppose that the specificity of the conditioning preparedness influenced the quality of the results. That is why we believe the results indicate high criterial validity of RSA protocol as a test of agility. These findings enable us to connect the measurement of agility and repeated-sprint ability into our test with intention to save the practice time.

We registered similar results for total time which was considered as an indicator of repeated-sprint ability of the players. The WHILL players are able to recover faster after each sprint in comparison to the players of the second highest league and well trained female university students. It seems that RSA protocol is in metabolic responses similar to those which occur during actual matches, such as the decrease in muscle pH, phosphocreatine and ATP, activation of anaerobic glycolysis and significant involvement of aerobic metabolism (Rampinini et al., 2007; Wragg, Maxwell, & Doust, 2000). For this reason, the use of RSA-based exercises for training and testing team sport athletes is increasing (Spencer et al., 2005). By cause of these results, we can use total time as an indicator of repeated-sprint ability of female handball players.

The S_{dec} parameter did not show any statistically significant results. According to Gabbett (2010), Spencer et al. (2006), and Glaister et al. (2009) S_{dec} showed low reliability, too. Therefore we think that total time is a better parameter to rate repeated-sprint ability of female handball players.

Conclussions

We ascertained that the specific handball repeated-sprint ability test protocol is a valid indicator of specific handball agility expressed by the index of agility and repeated-sprint ability expressed by total time. The sprint decrement seems not to be valid for the repeated-sprint ability indicator in handball.

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ANTHROPOMETRIC AND FITNESS DIFFERENCES IN THE FIRST SPANISH HANDBALL LEAGUE PLAYERS: PRELIMINARY STUDY

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Summary
The aim of the present study was to assess whether there are anthropometric characteristics differences between foreign, national team, and national players from the first Spanish Handball league. 40 women's handball players were studied. Foreign and National Team show higher values in anthropometric parameters than National first division players.

Introduction

Handball has been played in Olympic competition since the 1972 Games in Munich. The best leagues in the world are in Europe and the Spanish is one of the most important. To succeed in a sport, it is important usually to have specific bodily attributes (Malina, Bouchard and Bar-Or, 2004).

A number of previous studies have determined the anthropometrical profile of women's handball players from various National Teams (Bayios and Bergeles, 2006; Garcia et al, 2011; Gholami et al, 2010; Hasan et al, 2007). Recent studies also analyze the physical characteristics of different competitive levels (Granados et al., 2007; Granados et al, 2008; Milanese et al, 2011). These studies confirm that there are differences in anthropometric characteristics between the different levels of play.

Unfortunately, few studies have investigated the anthropometric characteristics between players in the same competitive level but with different roles and responsibilities within your team (foreign, national team, and national players). These results can provide relevant information to the coaches, to assess what are the best features to achieve the highest performance.

The aim of the present study was to investigate whether there are anthropometric characteristics differences between foreign, national team, and national players from the first Spanish Handball league. The results will provide (reflect the type of foreign players requirements suitable to play in Spanish clubs) valuable information concerning the demands of the Spanish clubs.

Methods

Data were collected concerning 40 women's handball players of the first Spanish league during the 2008/9 season. These players were divided into Foreign (13), National team A (11) and the rest of national players (16) of the first Spanish league. Goalkeepers were excluded.
All the players and trainers received verbal and written information about the study and gave informed written consent before anthropometric and conditional assessment. This study was approved by the San Antonio Catholic University Committee for research involving human subjects and carried out according of the Declaration of Helsinki.

Procedure
Anthropometric measurements were taken according to standardized procedures by an ISAK (International Society for the Advancement of Kinanthropometry) certified anthropometrist (Stewart, Marfell-Jones, Olds and Ridden, 2011). Dimensions included height, body mass, arm span, four breadths (biacromial, biepicondylar-humerus, biepicondylar-femur and bistyloid), five girths (arm relaxed, arm flexed and tensed, forearm, thigh, and calf). Measurement of anthropometric variable of hand width was a new original method reported by Visnapuu and Jürimäe (2007).

Height and body mass measurements were made on a set of scales (Seca, Barcelona, Spain) with an accuracy of 0.01 kg and 0.001 m, respectively. The girths were measured using a Lufkin metal tape (Lufkin Executive Thinline, W606PM, USA). The breadths and lengths were measured using an anthropometer (GPM, Siber Hegner, Zurich, Switzerland) with an accuracy of 0.01 cm.

Several variables were found: a) the body mass index (BMI) was calculated as weight (kg) divided by height (m^2), b) fat free mass (FFM) (kg) using the method described by Carter (Carter, 1982).

Results
Descriptive statistics of anthropometric characteristics of female handball players *according to the three level of play* are shown in Table 1. Foreign female handball players have higher mean values in years, experience, body mass, height and arm span variables, respect to the national players. Among players of the national team compared to national players, there is a tendency to the significance for the body mass and girth thigh.

Table 1. *Mean and standard deviations values ($\bar{x} \pm sd$) correspondent to anthropometric characteristics of women's handball players according to three level of play.*

Variables	**Foreing (13)**	**National team (11)**	**National players (16)**
Age (years)	27.5 ± 4.6	25.1 ± 5.2	25.4 ± 4.5
Experience (years)	16.1 ± 4.2	13.3 ± 4.0	15.4 ± 4.6
Height (cm)	175.7 ± 8.1	175.6 ± 8.0	167.0 ± 6.8 [a, b]
Body mass (Kg)	72.1 ± 7.4	71.5 ± 8.8	64.9 ± 7.7 [a]
Arm span (cm)	175.9 ± 13.1	175.9 ± 8.0	166.2 ± 10.9
Body composition			
BMI (%)	23.3 ± 1.0	23.1± 2.0	23.3 ± 2.3
Muscle Mass (kg)	45.2 ± 3.8	45.6 ± 2.3	45.5 ± 4.1
Girth (cm)			
Arm (relaxed)	29.4 ± 2.2	29.4 ± 2.6	30.4 ± 0.1
Arm (flexed and tensed)	30.4 ± 2.2	31.0 ± 2.2	29.2 ± 2.1
Forearm (maximum)	25.5 ± 1.3	24.9 ± 1.3	24.7 ± 1.3
Thigh (1 cm gluteal)	54.5 ± 5.3	52.4 ± 3.6	56.2 ± 3.8
Calf (maximum)	37.4 ± 2.8	36.3 ± 2.3	35.6 ± 1.9
Length (cm)			
Hand width	20.6 ± 1.9	20.7 ± 1.9	19.5 ± 0.8
Dominant hand	19.2 ± 1.3	19.1 ± 1.1	18.1 ± 1.5
Breadth (cm)			
Biacromial	38.1 ± 1.4	37.8 ± 1.8	36.5 ± 1.9 [a]
Bistyloid	5.4 ± 0.3	5.4 ± 0.2	5.2 ± 0.2
Biepicondylar humerus	6.7 ± 0.3	6.7 ± 0.4	6.3 ± 0.4 [a, b]
Biepicondylar femur	10.0 ± 0.5	9.6 ± 0.5	9.7 ± 0.5

Legend: *a= differences between national players and foreign players b= differences between national players and Spanish selection players (*) by* $p<0.05$.

Discussion

The data presented in this study should be analysed with caution, because they correspond to a preliminary study, therefore the sample is small. In the present study, anthropometric characteristics profiles were compared across three categories of Spanish women's team handball players participating in the First Spanish Handball League. Foreign and National Team show higher values in anthropometric parameters than National first division players. The results confirm the importance of the anthropometric characteristics in the elite female handball.

Foreign players and National team players had more advantageous anthropometric characteristics (body height, body mass, biacromial breadth_and biepicondylar humerus breadth) than National first division players. Although players did not show statistical differences, foreign and National players Showed higher values for arm span and hand length. These variables are not modifiable by training, and are related to benefits in the handball game (Zapartidis et al, 2009; Sroj, Marinovic and Rogulj, 2002; Vila et al, 2012), visual field, space occupation, advantages in the one against one, benefits in the struggle for space and for the management of the ball.

The height and weight presented by the foreign and national team players are similar to other studies carried out with professional teams (Manchado et al, 2007; Lian et al, 2005; Ronglan et al, 2005; Granados et al, 2007; Leyk et al, 2007) and superior to the French players (Filaire and Lac, 2000), Italian players (Milanese et al, 2011), Greek players (Zapartadis et al, 2009), Asian players (Hasan et al, 2007), and the Brazilian national team players (Vargas et al, 2008).The body fat percentage values found for subjects in this study were similar to those found in other studies with national teams or high-level female handball players (Milanese et al, 2011; Bayios et al, 2006).

We did not found differences in the fat or muscle percentage between the three levels of game analyzed (variables susceptible to be modified by training). These results confirm the importance of the levels of force in handball, where are actions such as sprints, jumps, blocking, pushing and rapid changes in moving directions (Hoff and Almasbakk, 1995; Ronglan et al, 2006; Granados et al, 2007; Vila et al, 2012).

Conclusions

These findings demonstrate that the anthropometric characteristics of handball players vary according to their performance level. This might have consequences for talent identification and team selection.

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PHYSICAL DEMANDS AND PHYSIOLOGICAL PROFILE IN FEMALE VS. MALE ELITE TEAM HANDBALL PLAYERS: HOW BIG IS THE DIFFERENCE?

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Summary
The present study demonstrated substantial gender-specific differences in the physical demands in elite team handball, with male players performing more high-intense, strength-related playing actions and high-intensity running than female players. Conversely, female players covered a greater total distance and worked with a higher relative work load than male players. Consequently, physical training of male elite team handball players may in contrast to female players benefit from gaining a greater focus on anaerobic and strength training elements with relative less attention on aerobic training.

Keywords
Computerized match analysis, physiological measurements, physical testing, body anthropometry, gender-specific differences

Introduction
Modern elite team handball (TH) is a physically demanding contact team sport, which is characterized by sixty minutes of fast, intense and dynamic activities such as repeated accelerations, sprints, jumps, shots, rapid changes in directions and high amounts of body contact between players. To plan and implement effective physical training in top level TH players, it is necessary to know the physical working demands of the game. A complete analysis of the physical working demands of modern elite TH have recently been conducted separately for male and female elite players (Michalsik et al., 2013a,b,c,d,e).

It is well known that physiological differences exist between the sexes, since men in general are taller, heavier with larger muscle mass, stronger, faster and have a higher VO_2-max than women. However, these differences do not have any impact on the TH game itself as no match under normal circumstances is played against someone of the opposite sex. So the question arises, whether from a physical point of view differences exist between the physical demands imposed by male and female elite TH match-play, respectively. If this is the case, physical training in TH may be designed and performed in ways that more accurately reflect the specific demands placed on male (MP) and female players (FP), respectively.

In top level TH, it does not appear in the world of practice that the central areas of physical training differ depending on, whether the coaches are dealing with MP or FP. However, to our best knowledge no data have been published on gender-specific differences in the physical demands in elite TH. Consequently, there is a need to examine the potential differences in the physical demands of modern elite TH between MP and FP thoroughly in order to evaluate, if the physical training for MP should differ from that of FP. The aim of the present study, therefore, was to identify potential gender-specific differences in the physical demands imposed on players during modern elite TH match-play. The study was conducted by comparing the working demands in modern male elite TH (Michalsik et al., 2013a,b,c) with a corresponding analysis of the working demands in modern female elite TH (Michalsik et al., 2013d,e). Both analyses used the exact same experimental methods.

Methods

Subjects

A large group of male and female elite TH players were recruited for the study from teams ranked in the upper half of the Danish Premier Team Handball League. A majority of the participants played at the international top level. All players were fully informed of all experimental procedures and possible discomforts associated with the study before giving their written informed consent to participate. The conditions of the study were approved by the local Ethics Committee. The MP and FP were examined over a six-year and a five-year period, respectively. The study was carried out during the entire tournament match season (September to May, players performing 6-10 training sessions and 1-2 matches per week). No year-to-year differences were observed during the whole study period for any of the analysed parameters.

Observations during match play - video recordings

Observations during match-play took place by means of video recordings (mainly of field players) as described in detail elsewhere (Michalsik et al., 2013a,b). In brief, one camera followed one player without interruption throughout the entire course of the match regardless what the player did. 62 vs. 46 tournament matches in the Danish Premier Male vs. Female Team Handball League were monitored. On average 4 players were recorded per match, which provided a total of about 420 recordings. We aimed to only include players with substantial playing time, in order to ensure that their activity pattern would reflect the true physical demands of the game. The inclusion criteria, therefore, was determined as being an effective playing time for the whole match of 42 min or more (i.e. ~70 % of total effective playing time (TPT)) with an effective playing time in one half of the game of 18 min or more (i.e. ~60 % of TPT). A total of 82 recordings of MP and 84 recordings of FP fulfilled these conditions and were analysed according to the established criteria (Michalsik et al., 2013a,b).

The present computerized match analysis focused separately on offensive and defensive playing actions, where field players were divided into three categories, wing players, pivots and backcourt players, respectively. Each match was analysed twice for each of the players. The first computerized analysis included locomotion match characteristics (running types, intensity and distance). A total of 8 locomotive categories were registered. The selected speeds were the same for all players, but a little higher in most categories for MP compared to FP.

Since TH involves large amounts of physical confrontations, computerized technical match analysis (technical playing actions) of each game was conducted to avoid an underestimation of the quantity of movement. Six types of playing actions were registered. The playing actions comprised shots, breakthroughs, fast breaks, tackles, technical errors and defence errors. Each playing action was further divided into a number of sub-categories (e.g. hard or light tackles, clapings, screenings, the type of shots), all of which were precisely defined. For both match analyses, a special designed for computer based analysis program for TH was used. More details about the video analyses are given in (Michalsik et al., 2013a,b).

Physiological measurements during match-play and physical testing

The physiological work load during matches in the Danish Premier Male vs. Female Team Handball League was registered by continuous HR monitoring in successive 5-s intervals. On a separate day, an incremental treadmill running test was performed, which consisted of a submaximal test followed by an exhaustive incremental maximal test (all-out test) (Michalsik et al., 2013c,d). Respiratory measurements were conducted using online analysis. HR was continuously recorded in 5-s intervals throughout the test. The individual HR-VO_2 relationship obtained during the treadmill test (correlation equation $y = a \cdot x + b$) was used to estimate VO_2 during match-play based on the HR recording obtained during match-play. Subsequently, relative work load during match-play could be determined expressed as % of VO_2-max. In addition, the Fitness Index (ml $O_2 \cdot min^{-1} \cdot kg^{-0.73}$) was calculated.

Body anthropometry

Anthropometric data (body mass, body height) were recorded from all teams of the Danish Premier Male vs. Female Team Handball League in the first season (n=120) and in the fourth season (n=157) for FP and in the first season (n=152) and in the fifth season (n=191) for MP. Furthermore, information about the individual players´ age, playing position, player choice (first or second choice) and playing experience (years of playing) at the adult elite level were obtained. All data are expressed as group mean values ± standard deviations (SD). The statistical level of significance was set at $p \leq 0.05$ using a two-tailed test design.

Results

Locomotion characteristics, physiological measurements and physical testing

Marked differences were observed in the movement pattern between MP and FP during match-play (Table 1). MP performed more high-intensity running (1.7±0.9 % of TPT) than FP (0.8±0.5, p<0.001, effect size (d-values designated as ES) =1.24) and also more sideways movement (7.4±2.7 % of TPT) and backwards running (1.4±0.8 % of TPT) compared to FP (1.8±1.3 %, p<0.001, ES=2.64; 0.6±0.4 %, p<0.001, ES=1.26). FP covered a greater total distance per match (4002±551 m) than MP (3627±568 m, p<0.05, ES=0.67) in spite of that the analysed matches for FP were in average were 3.15 min shorter compared to MP. The same picture emerged when comparing full-time players (60 min playing time; 4693±333 m vs. 3945±538 m, p<0.01, ES=1.67). FP worked with a greater relative work load during their time on the court (79.4±6.4 % of VO_2-max) than MP (70.9±6.0 %, p<0.05, ES=1.37), but did less amount of high-intensity running per match (2.5±1.8 % of total distance covered) than MP (7.9±4.9 %, p<0.01, ES=1.46). Furthermore, FP worked with a lower mean speed (5.31±0.33 $km \cdot h^{-1}$) and had fewer mean number of activity changes (663.6±100.1) compared to MP (6.40±1.01 $km \cdot h^{-1}$, p<0.001, ES=1.45; 1482.4±312.6, p<0.001, ES=3.53). Regardless of how it was expressed, MP had as expected higher oxygen uptake than FP (Table 2).

Position specific locomotion match profile

For both MP and FP several differences were observed between various playing positions. Among MP, backcourt players (3765±532 m, p<0.05, EA=0.91) and wing players (3641±501 m p<0.05, ES=0.69) covered a greater total distance than pivots (3295±495 m), while female pivots were more agile and performed relative more running. Among FP, pivots (4067±485 m, p<0.05, ES=0.45) together with wing players (4086±523 m, p<0.05, ES=0.47) performed a greater total distance covered than backcourt players (3867±386 m). In both sexes, wing players performed more high-intensity running (MP 10.9±5.7 %, FP 3.6±1.5 % of total distance covered) than pivots (8.5±4.3 %, p<0.05, ES=0.48; 2.3±1.5 %, p<0.01; ES=0.87) and backcourt players (6.2±3.2 %, p<0.01, ES=1.02; 1.3±0.9, p<0.01, ES=1.86).

Technical match profile, anthropometric characteristics and position specific differences

Gender differences were observed in the technical match analysis (Table 3) and in body anthropometry. In offence, MP performed more fast breaks (6.0±4.2) than FP (2.8±2.6, p<0.001, ES=0.92), received more tackles in total (hard and light tackles combined, 34.5±21.3) than FP (14.6±9.2, p<0.001, ES=1.21) and did less technical errors (1.5±1.3) compared to FP (2.9±2.3, p<0.05, ES=0.75). In defence, MP performed more tackles in total (29.9±12.7) than FP (20.7±9.7, p<0.01, ES=0.81) and did more claspings (3.9±3.0) and screenings (6.1±3.1) compared to FP (1.9±2.7, p<0.01, ES=0.70; 4.2±3.7, p<0.05, ES=0.56). In total, MP performed a higher number of high-intense playing actions per match (36.9±13.1) than FP (28.3±11.0, p<0.05, ES=0.71).

Several differences were observed between the various playing positions for both MP and FP of which the most marked was that wing players both for MP and FP had less physical confrontations in offence and in defence than backcourt players and in particularly pivots. Additionally among FP, wing players performed more fast breaks (4.4±2.8) than pivots (2.5±1.8, $p<0.01$, ES=0.81) and backcourt players (1.0±1.3, $p<0.01$, ES=1.56), while in MP, pivots (8.3±4.0) performed just as many fast breaks as wing players (8.9±3.1) and markedly more than backcourt players (3.4±3.2, $p<0.05$, ES=1.35).

Mean body height and body mass were substantially higher in the Danish Premier Male vs. Female Team Handball League (189.6±5.8 cm, 91.7±7.5 kg vs. 175.4±6.1 cm, $p<0.001$, ES=2.39; 69.5±6.5 kg, $p<0.001$, ES=3.16; mean difference 14.2 cm and 22.2 kg, respectively). For both sexes wing players were lighter, smaller, younger and less experienced on adult elite level than the rest of the players including goalkeepers, and pivots were heavier and taller than the rest of the field players. No difference was seen in age and adult elite playing experience between the two sexes. In both sexes for all players combined (and in the various playing positions), no differences in body height and body mass between the two choices of players were observed, but first choice players were older and more experienced ($p<0.001$) than second choice players.

Table 1. *Gender differences in offensive and defensive locomotive actions in total per match for male (n=82) and female elite team handball players (n=83) separated into in the eight movement categories. Results are mean.*

Offensive and defensive locomotive actions in total per match		
	Male players (n=82) % of total playing time per match	Female players (n=83) % of total playing time per match
Playing time (min)	53.85	50.70 *
Standing still	36.8	10.8 **
Walking	39.6	62.3 **
Jogging	8.6	18.8 **
Running	4.4	4.9
Fast running	1.4	0.7 **
Sprint	0.4	0.1 **
Sideways movement	7.4	1.8 **
Backwards running	1.4	0.6 *
Total	100.0	100.0

*Difference between male and female players * $p<0.05$ and ** $p<0.001$.*

Table 2. *Gender differences in selected categories of the physical demands during match-play (group means ± SD) between Danish male and female elite team handball players.*

Gender differences in physical demands during match-play		
	Male players (n=82)	Female players (n=83)
Mean effective playing time (min)	53.85±5.87	50.70±5.83 *
Total distance covered (m)	3627±568	4002±551 *
Total distance covered, full-time players (m)	3945±538	4693±333 **
High-intensity running (% of total distance covered)	7.9±4.9	2.5±1.8 **
Standing still (% of total playing time)	36.8±8.6	10.8±3.8 ***

Sideways movement (% of total playing time)	7.4±2.7	1.8±1.3 ***
Mean speed ($km \cdot h^{-1}$)	6.40±1.01	5.31±0.33 **
Activity changes (number)	1482.4±312.6	663.6±100.1 ***
Relative work load (% of VO_2-max)	70.9±6.0	79.4±6.4 *
VO_2-max ($l\ O_2 \cdot min^{-1}$)	5.18±0.66	3.49±0.37 ***
VO_2-max ($ml\ O_2 \cdot min^{-1} \cdot kg^{-1}$)	57.0±4.1	49.6±4.8 ***
Fitness Index ($ml\ O_2 \cdot min^{-1} \cdot kg^{-0.73}$)	192.6±18.2	156.4±15.3 ***

*Difference between male and female players * p<0.05, ** p<0.01 and *** p<0.001.*

In the second half both MP and FP demonstrated a decrease in the amount of high-intensity running, in HR and relative work load during match-play and in the number of high-intense playing actions, which indicates for both sexes, that for players with TPT over 50 min per match temporary fatigue might occur.

Table 3. *Gender differences in offensive and defensive technical playing actions in total (group means ± SD) for the entire match for male (n=82) and female elite team handball players (n=84).*

Technical playing actions	Male players (n=82) Number per match	Female players (n=84) Number per match
Offensive actions - 1. half and 2. half in total		
Playing time (min)	26.18±3.13	24.57±4.33
Offensive breakthroughs	1.5±1.4	1.3±2.2
Fast breaks	6.0±4.2	2.8±2.6 **
Technical errors	1.5±1.3	2.9±2.3 *
Hard checking	7.5±4.4	5.0±4.0 *
Light checking	27.0±18.4	9.6±6.2 **
Clasping	2.7±1.9	1.2±2.0 *
Screenings	4.8±8.3	7.9±9.8*
Shots	8.5±4.2	7.7±3.7
Scoring percentage	44.9±17.7	51.9±21.4
Defensive actions - 1. half and 2. half in total		
Playing time (min)	27.67±3.18	26.13±3.85
Hard checking	5.8±3.6	6.2±3.8
Light checking	24.1±12.6	14.5±7.4 *
Clasping	3.9±3.0	1.9±2.7 **
Screenings	6.1±3.1	4.2±3.7 **
Blocks	3.7±3.5	3.5±3.8
Defensive errors	3.8±2.5	5.1±3.2 *

*Difference between male and female players * p<0.05 and ** p<0.001.*

Discussion

Locomotion activity pattern

Based on the present results, clear gender differences were observed in locomotion activity pattern of male vs. female elite TH players during actual match-play. During organized attack, FP appeared to play in a relatively uniform pace with the players frequently walking, but rarely were standing still. Likewise, FP demonstrated few intense tempo changes and changes in direction accompanied by relatively few fast breaks. Consequently, the amount of high-intensity running did not represent much of TPT. On the other hand, numerous changes in ball procession resulted in a lot of transition running involving rapid shifts in defence and offence actions. FP showed less playing time spent in the organized attack explaining the high occurrence of transition running between offence and defence in these players. This is partly due to poorer technical skills in FP compared to MP, which is reflected in the higher number of technical errors in FP. FP performed over twice as many technical errors per player and hence also per team as MP. More technical errors cause more switching between attacks and defence and results in more continuous running with moderate intensity. The high total distance covered and the low number of activity changes indicates that elite female TH players perform large amounts of un-interrupted running during much of the match, resulting in a relatively higher aerobic load. In contrast, the fewer fast breaks and activity changes and thus shifts of tempo and direction results in less anaerobic load being placed on the lower extremities.

Conversely, male elite TH players were characterized by a relatively steady pace of locomotion in the organized attack, with players frequently standing still or walking. However, match-play still involved numerous intense tempo changes and changes in direction, which together with the relatively many fast breaks caused high-intensity running to represent a relatively high fraction of total distance covered, altogether suggesting that the ability to change pace and accelerate in specific game actions is very important for playing performance. Male elite TH match-play showed substantially more intermittent activity pattern compared to female elite TH, as demonstrated by the more than two-fold higher number of activity changes in MP. In result, male elite TH players were characterized by running patterns with a markedly higher anaerobic load, but with a lower aerobic load compared to female elite TH players. Notably, MP performed substantially more sideways movement both in offence and defence compared to FP, maybe due to need for high muscle strength in the lower extremities in order to perform fast sideway displacements carried out deep down in the legs.

There were both similarities and differences at the various playing positions. Female pivots e.g. covered a high total distance, because during offence and defence these players showed only minor periods of standing still (~10 % of TPT). Instead they mostly walked or performed a little running. In addition, they performed an average amount of high-intensity running and number of fast breaks. In contrast, male pivots covered a low total distance due to a high amount of standing still (~40 % of TPT). When moving, however, they showed relative high mean speed and performed high amounts of high-intensity running with many fast breaks and retreats. Thus, female pivots in general appear to be more agile than their male counterparts, however during their active periods male pivots seem to move with greater intensity (higher speed).

Technical match profile and body anthropometry

The technical match analysis revealed that both in offence and defence the amount of high-intense playing actions and physical confrontations with opponents were markedly less for FP compared to MP. The fewer high-intense, strength-related playing actions suggest that with FP both the upper and the lower extremities are exposed to a less anaerobic load. Although a need still exist to work with high intensity (anaerobic work) and using large physical strength in FP, this need appears to be much less compared to MP. The differences between various playing positions were almost similar in FP and MP, and in both sexes wing players had considerable less body contact in both offence and in defence than both backcourt players and in particularly pivots.

The differences in the strength-related playing actions are in line with the differences in anthropometry between the two sexes. MP showed markedly higher body mass and body height than their female counterparts. With substantially larger, heavier and stronger players it is not surprising that the amount of physical confrontations is higher among MP. Larger and heavier MP takes up relatively more space on the court. Consequently, this increases the possibility of more physical confrontations among MP.

Although clear differences in the physical demands between MP and FP were observed, it appears that players of both sexes with a TPT over 50 min per match were experiencing fatigue during match-play.

Conclusions

In conclusion, the present study demonstrated considerable gender-specific variations in the physical demands in modern elite team handball, and in addition clearly indicated that the physical demands differ greatly between various playing positions both in defence and attack in the same manner for both male and female elite players. Consequently, physical training of female elite team handball players may benefit from gaining a greater focus on aerobic training elements with relative less focus on anaerobic training and strength training. Conversely, male elite team handball players could benefit from an increased training focus on anaerobic exercise elements and strength training, while focusing relative less on aerobic training drills.

Alternatively, female elite team handball may be developed into a more intermittent and high-intensive game, with more physical confrontations with opponents, i.e. converging towards the characteristics of male elite team handball match-play. This approach would require female players in their daily training to focus more intensively on the areas of physical training that are pivotal to male players (anaerobic training, strength training). Regardless of gender, however, the planning and execution of physical training should be individually adjusted to the specific playing position and the players´ individual physical capacity.

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PHYSICAL DEMANDS OF TRAINING AND MATCH-PLAY IN THE FEMALE ELITE TEAM HANDBALL PLAYER

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Part 1 - Physical demands of match-play

Summary
The present match observations revealed that modern female elite team handball is a physically demanding intermittent team sport, where players are exposed to high relative workloads with substantial estimated aerobic energy expenditure interspersed by short periods of dominant anaerobic energy production. Indications of fatigue were identified. In addition, positional physical differences during match-play and in body anthropometry were observed.

Keywords
Computerized match analysis, high-intensity running, physical confrontations, body anthropometry, positional differences

Introduction

The requirements for female elite team handball (TH) players have changed as the game of TH has evolved substantially over the last decades. The amount of training and the number of matches have increased considerably and recently introduced rule changes, e.g. the quick throw-off, have led to an increased number of attacks during match-play. This has contributed to elevate the intensity of game-play and to increase the physical demands imposed on the players. Consequently, modern elite TH has transformed into a fast and intense game performed by well-trained players, who must be able to perform many different movements such as running, side-cutting, jumping, shooting, change of directions and technical playing actions with a high degree of physical contact with opponents. Caused by the marked development in the game over the recent years, it is a precondition to perform a profound working demand analysis of the game in order to identify the exact requirements for the players on the court. Such prior knowledge provides the needed basis for the planning and execution of effective training (Michalsik, 2004).

The aims of the present study, therefore, were (i) to determine the physical and physiological demands placed on female elite TH players, (ii) to evaluate the physiological profile of female elite TH players, (iii) to identify positional differences in all these parameters and in body anthropometry, and (iv) to examine if physical match performance is impaired during an elite TH match. As the activity patterns of goalkeepers obvious differ substantially from those of field players, the physical demands placed on goalkeepers were not examined.

Methods

Subjects

Female elite TH players were recruited for the study from teams ranked in the upper half of Danish Premier Female Team Handball League, which is considered to rank among the top-leagues in international female TH. All players were fully informed of all experimental procedures and possible discomforts associated with the study before giving their written informed consent to participate. The conditions of the study were approved by the local ethics committee. The study was carried out during the entire tournament match season during a five-year period (September to May, players performing 6-10 training sessions and 1-2 matches per week). No year-to-year differences were observed during the five-year study period for any of the analysed parameters.

Observations during match-play - video recordings

Each player was evaluated during match-play using video based computerized locomotion and technical match analysis of tournament matches as described in detail elsewhere (Michalsik et al., 2013a,b). Altogether 46 tournament matches were video-filmed using multiple cameras, which provided a total of about 180 player recordings in the Danish Premier Female Team Handball League. We aimed to only include players with substantial playing time, in order to ensure that their activity pattern would reflect the true physical demands of the game. Inclusion criteria, therefore, were determined as being an effective playing time for the whole match of 42 min or more (i.e. ~70 % of total effective playing time (TPT)) with an effective playing time in one half of the game of 18 min or more (i.e. ~60 % of TPT). A total of 84 recordings fulfilled these conditions and were analysed according to the established criteria (Michalsik et al., 2013a,b).

The present computerized match analysis comprised assessment of locomotion characteristics (running types, intensity and distance) and technical match analysis (technical playing actions) separately in offensive and defensive playing actions, respectively, where field players were further divided into three categories, wing players (WP), pivots (PV) and backcourt players (BP), respectively. A total of 8 locomotive categories were registered. The movement categories and corresponding speeds were low-intensity activities (standing still (0 $km \cdot h^{-1}$), walking (4 $km \cdot h^{-1}$)), moderate-intensity activities (jogging (7 $km \cdot h^{-1}$), sideways movement (9 $km \cdot h^{-1}$), backwards running (9 $km \cdot h^{-1}$), running (12 $km \cdot h^{-1}$)), and high-intensity running (fast running (15.5 $km \cdot h^{-1}$), sprinting (22 $km \cdot h^{-1}$)). Furthermore, a total of 6 types of technical playing actions were registered in the technical match analysis. The playing actions comprised shots, breakthroughs, fast breaks, tackles, technical errors and defence errors. Each playing action was further divided into a number of sub-categories (e.g. hard or light tackles, type of shot, clapings, screenings, blockings), all of which were precisely defined**.** For both match analysis, a special designed analysis program for computer based analysis of TH was used. More details about the video analyses are given in Michalsik et al., 2013a,b.

Physiological measurements during match-play and physical testing

The physiological work load during matches in the Danish Premier Female Team Handball League was registered by continuous HR monitoring in successive 5-s intervals. On a separate day, an incremental treadmill running test was performed, which consisted of a submaximal test followed by an exhaustive incremental maximal test (all-out test) (Michalsik et al., 2013c,d). The individual HR-VO_2 relationship obtained during the treadmill test (correlation equation $y = a \cdot x + b$) was used to estimate VO_2 during match-play based on the HR recording obtained during match-play. Subsequently, relative work load during match-play could be determined expressed as % of VO_2-max. In addition, the Fitness Index (ml $O_2 \cdot min^{-1} \cdot kg^{-0.73}$) was calculated. The ability to work intensely and to recover quickly after intense work bouts were assessed on the TH court using the Yo-Yo intermittent recovery test, level 1 (Yo-Yo IR1-test). A pre-study familiarization test round was performed in all players.

Body anthropometry

Anthropometric data (body mass, body height) were recorded from all teams of the Danish Premier Female Team Handball League in the first season (n=120) and in the fourth season (n=157). Furthermore, information about the individual players´ age, playing position, player choice (first or second choice) and playing experience (years of playing) at the adult elite level were obtained.

All data are expressed as group mean values ± standard deviations (SD). The statistical level of significance was set at $p \leq 0.05$ using a two-tailed test design.

Results

A total distance of 4002±551 m (group means±SD) was covered per match with a TPT of 50.70±5.83 min, while full-time players covered 4693±333 m. Both WP (4086±523 m, effect size (d-values designated as ES) =0.48) and PV (4067±485 m, ES=0.46) covered a greater total distance per match ($p<0.05$) than BP (3867±386 m). No difference was observed in total distance covered (TDC) between the first (2010±362 m) and the second half (1993±382 m). On average, each player (n=83) performed 663.8±99.7 activity changes per match. Standing still and walking combined constituted 73.1±4.8 % of TPT per match. In contrast, high-intensity running constituted 0.8±0.5 % of TPT per match corresponding to 2.5±1.8 % of TDC. The amount of high-intensity running was reduced ($p<0.05$) 21.9 % in the second half (44.9±16.8 m) compared to the first (57.5±21.3 m). WP performed more high-intensity running (3.6±1.5 % of TDC) than PV (2.3±1.5 %, $p<0.01$, ES=0.87) and particularly BP (1.3±0.9 %, $p<0.001$, ES=1.86). High-intensity running constituted 3.3±1.2 % of TDC among full-time players.

Maximal oxygen uptake (VO_2-max) was 3.49±0.37 l $O_2 \cdot min^{-1}$ corresponding to 49.6±4.8 ml $O_2 \cdot min^{-1} \cdot kg^{-1}$. Expressed relative to body mass (ml $O_2 \cdot min^{-1} \cdot kg^{-1}$) or as Fitness Index (ml $O_2 \cdot min^{-1} \cdot kg^{-0.73}$), VO_2-max did not differ between playing positions. Mean relative work load during match-play was 79.4±6.4 % of VO_2-max. Positional differences were demonstrated, where PV played with a higher mean relative work load (83.1±4.9 % of VO_2-max) than WP (78.4±5.9 % of VO_2-max, $p<0.05$, ES=0.87) and BP (75.8±6.5 % of VO_2-max, $p<0.01$, ES=1.27). Relative work load during match-play was higher in the first than in the second half of the match for all players combined (81.0±4.7 vs. 77.5±5.1 of VO_2-max, $p<0.001$, ES=0.71) and for WP (80.5±5.1 vs. 75.9±5.4 of VO_2-max, $p<0.001$, ES=0.88), PV (84.4±5.2 vs. 81.8±4.6 of VO_2-max, $p<0.01$, ES=0.53) and BP (77.4±4.8 vs. 73.7±5.6 of VO_2-max, $p<0.001$, ES=0.71), respectively. Mean total running distance in the Yo-Yo intermittent recovery test (level 1) was 1436±222 m, which was greater in WP (1516±172 m, $p<0.05$) than PV (1360±118 m) and BP (1352±148 m).

Each player had 28.3±11.0 high-intense playing actions per match. In offense, each player made 2.8±2.6 fast breaks, gave 7.9±14.4 screenings, received 14.6±9.2 tackles in total and performed 7.7±3.7 shots along with 3.5±3.8 blockings, 1.9±2.7 claspings and 6.2±3.8 hard tackles while in defence. Technical match actions differed between various playing positions Notably, WP performed considerable more fast breaks and had substantially less physical confrontations than BP and particularly PV. Mean body height, body mass and age in the Danish Premier female Handball League were 175.4±6.1 cm, 69.5±6.5 kg and 25.4±3.7 years, respectively. WP were lighter (63.5±4.8 kg, $p<0.001$) and smaller (169.3±4.9 cm, $p<0.001$) than BP (70.6±5.3 kg, 177.0±5.4 cm) and PV (72.5±4.9 kg, 177.7±4.9 cm).

Discussion

The present study demonstrated that modern female elite team handball impose high aerobic demands on the players as evidenced by a high relative work load (~80 % of VO_2-max**)** interspersed by very brief time periods of substantial anaerobic energy production as reflected by a limited amount of high-intensity running (~2.5 % of TDC per match) making modern male elite Team Handball a physically demanding intermittent team sport. The high relative work load may partly be due to the players running for a large proportion of the match with attention fixed on the ball or directly with the ball, which increases VO_2 (Reilly & Ball, 1984). Thus, female players engage in a number of intensive activities such as combinations of running, sprinting, jumping, throwing and regular in-fights (pushing and clasping) with opponents. Based on the number of high-intense playing actions, higher anaerobic demands likely were placed on players who played WP in offense and covered BP in defence than in players who played BP in offense and covered WP in defence. This suggests that the teams' tactical approach influence the players´ physical requirements in elite TH.

Furthermore, female elite Team Handball is a complex game also characterized by a high number and a great variety of short-term, high-intense technical playing actions that are performed intermittently throughout the entire match. Although low-intensity activities (standing still, walking) constituted ~73 % of mean effective playing time, players demonstrated a mean relative work load ~80 % of VO_2-max during the periods of effective match-play. This indicates that the amount of high-intensity, strength related technical playing actions had a marked influence on the high HR values and hence on the relative work load without contributing substantially to TDC. Playing actions such as tackles, offensive breakthroughs, claspings and screenings may result in elevated HR for more extended periods of time (due to elevated HR in the subsequent recovery phase). Consequently, using only the findings from locomotion match analyses will likely underestimate the physical demands of elite TH match-play. A high level of aerobic power and capacity allows the individual player to play at a high tempo. Although a high aerobic performance may not per se be the decisive physical factor during the actual game, it also improves the ability to tolerate a high intensity and quality of the daily training along with a high overall total training volume and to recover in long tournaments with numerous matches in a short period of time (Michalsik & Bangsbo, 2002).

The decrease in the total number of high-intensity activity changes, the amount of high-intensity running, mean speed, HR and relative work load in the second half of the match collectively indicates that temporary fatigue (decrease after the most intense periods) and maybe a more permanent form of locomotive fatigue (decrease towards the end of the game) and impaired physical performance may have occurred, at least in players with more than 50 min playing time per match.

Moreover, extensive positional differences were observed in the physical demands during match-play, where WP covered a greater total distance than BP and performed more high-intensity running and demonstrated a better intermittent recovery capacity (Yo-Yo test outcome) compared to both BP and PV. Running training in female elite TH should therefore be organised in a way that it accounts for the specific playing positions, while also recognizing the players´ individual level of physical capacity and recovery profile.

Furthermore, WP performed more fast breaks than BP and PV. Mimicking the activity pattern seen in offense, the incidence of physical confrontations in defence (tackles, screenings, claspings and blocks) differed in the order PV>BP>WP. Female elite Team Handball is a highly strenuous body-contact team sport, where body anthropometry plays an important role for playing performance, with various influence at the different playing positions. The technical match analysis indicated possible causes as to why some playing positions differ anthropometrically from others. Based on the available data, female elite TH players have become higher and heavier probably with increased muscle mass compared to past time players. The present data demonstrated that female elite TH players are highly active during match-play performing a large number of intense physical confrontations both in offense and defence, which presumably require high mobility/agility as well as high levels of muscle strength and rapid force characteristics (rate of force development, RFD). A number of these technical playing actions were performed with short duration and high intensity and, therefore, most likely imposed high demands on anaerobic energy sources in the active muscles.

The present findings may be used to design training regimens that can maximize the position-specific physical development in female elite TH players. In addition, an increased and differential focus to improve high-intensity intermittent exercise capacity would seem relevant to ensure optimal individual development in the physical capacity of elite team handball players.

Conclusions
In conclusion, modern female elite team handball is a physically demanding intermittent team sport, which during match-play imposes high aerobic demands on the players as evidenced by a high relative work load interspersed by very brief time periods of substantial anaerobic energy production as reflected by short-term, high-intense technical playing actions and a limited amount of high-intensity running. Furthermore, the players perform a high number of short-term, high-intense technical playing actions intermittently throughout the entire match. Signs of temporary fatigue and impaired physical performance were observed. Major individual differences in physical demands were demonstrated between playing positions both in offense and defence, with WP demonstrating more intensive activity pattern than BP and PV. Indications of temporary locomotive fatigue and impaired physical performance were observed. Body anthropometry differed substantially between playing positions.

Part 2 - Training of a female top-elite team handball player

Due to an increasing intensity of the game, the physical demands of modern female elite team handball during match-play plays a relatively larger role in players' total performance capacity than decades ago. Consequently, the specific design and implementation of physical training in team handball represent an essential tool to exploit and sustain player's technical and tactical qualities throughout an entire game. In addition, an improved level of physical capacity enables players to train at increased intensity and in achieving a large total quantity of training. Based on the demand analysis of the game it is clear that high-intensity running exercises should be in focus in the training of female elite team handball players for improving elite players' ability to repeatedly perform intense exercise and to rapidly recover after periods of high-intensity exercise. This is done by performing aerobic and anaerobic training on a regular basis. In addition, due to the apparent relative high demands in e.g. acceleration and deceleration capacity, rate of force development (RFD), fast and hard shots, rapid side cutting manoeuvres and the high number of strength demanding physical confrontations (i.e. pushing and holding), an intensified focus on resistance training and on anaerobic training aspects seem highly relevant for female elite team handball players. The former training should comprise both basic strength training and RFD-training and carried out to make the players capable of performing these above playing actions throughout the entire match. An increased focus on anaerobic training seems to be relevant due to the fact that for some players there seems to be a development of temporary fatigue during match-play.

Significant anthropometric development has taken place in female elite team handball, where today's players are markedly taller and heavier than 30 years ago. Concurrently with this development it is vital for female elite team handball players that their functional characteristics on the playing court (i.e. agility and sprint/jump/endurance abilities) are not compromised due to their larger and heavier body. Thus, players have to preserve or even improve their acceleration capacity, ability to perform rapid side cutting manoeuvres, maximum jump height and mobility as well as aerobic power at the same time as becoming heavier to push away in a break-through and are able to tackle opponents harder in defence. Consequently, adequate specific physical training regimens to improve these functional capacities should be implemented including e.g. on-court sprinting, jumping and intermittent endurance and strength/RFD exercises. Such individual training design may be divided into separate physical training exercises related to the specific requirements in offense and defence, respectively. It is important that the improvements achieved by physical training can be transferred to the actual team handball game on court. Thus, physical training in team handball should as far as possible take place with a ball, since such training has several advantages. Firstly, the muscle coordination and the specific muscle groups used in team handball will be trained. In addition, the players' technical and tactical abilities will be developed under conditions relevant to the game. Furthermore, training with a ball will be more motivating for most players.

The present findings of positional differences may be useful in the implementation of training regimens to optimize the position-specific physical training in female elite team handball. Consequently, specific physical training should be implemented at the various playing positions to ensure optimal development of the physical capacity of individual players. Physical training is a supplement to actual team handball training. It is, therefore, a matter of utilising the time for physical training to the maximum. Overall taken, female elite players should perform specific training in relation to their playing position, individual capacity and training status and need for restitution, and additionally to focus especially on the enhancement of their functional physical performance on the team handball court through intense strength and aerobic/anaerobic training. The total training dosage should also be individualized, since the training load during team training may be appropriate for some, but respectively too little or too much for others. Improvement in the players' physical capacity will mean that the trainer will carry out a substitution during the game first and foremost on the basis of tactical considerations. The increased knowledge regarding the physical demands of female elite team handball players is important for evidence-based recommendations for the future planning and execution of physical training.

In a typical week for an female professional top-elite handball team with one match to play, the players have 7-8 training sessions in 5 days (i.e. 2-3 days with two sessions), often with the day after the match free. If there is a second match in midweek, the team often trains only 1-2 days with two training sessions. However, there are marked variations depending on the experience of the coach and the training status of individual players. Table 1 presents examples of programmes for an international top-class team during the tournament season. To obtain information about the loading of the players, monitoring of the heart rate can be used. However, such measurements do not provide a clear picture about the anaerobic energy production during training due to the short duration of the anaerobic exercises. The following is an example of the heart rate response for two top-elite female team handball players during high-intensity aerobic training (drill "repeated fast breaks/quick retreats", 3 players continuously performing fast breaks and quick retreats) consisting of 3 min exercise periods separated by 1 min recovery periods. The length of time the heart rate was 80-90, 90-95, and 95-100% of maximal heart rate was 5.7, 8.8, and 3.9 min, respectively, for one player, and 3.7, 10.1, and 4.7 min, respectively, for the other player. In addition, it is also important to perform measurements in training sessions that are not specifically designed to improve the fitness of the players. This may be used to estimate the mean energy expenditure and should be taken into account when planning nutritional strategies for individual players.

Table 1. *An in-season weekly programme for a professional female top-elite team handball (TH) team when playing one or two tournament matches a week.*

Day	One match a week	Two matches a week
Saturday	Match	Match
Sunday	Free	Individual physical training - low/moderate intensity aerobic training, 30 min and strength training (RFD-training), 45 min
Monday	*Morning* Individual physical training - strength training (RFD-training), 60 min *Afternoon* Tactical/technical TH training with anaerobic tolerance training, 90 min	*Morning* Tactical/technical TH training with jump training, 90 min *Afternoon* Tactical/technical TH training with anaerobic production/tolerance training, 90 min
Tuesday	*Morning* Individual physical training - high-intensity aerobic training, 30 min Tactical/technical TH training, 60 min *Afternoon* Tactical/technical TH training with jump training, 90 min	*Morning* Tactical/technical TH training, 90 min *Afternoon* Individual physical training - strength training (RFD-training), 45 min
Wednesday	*Morning* Individual physical training - strength training (RFD-training), 60 min *Afternoon* Tactical/technical TH training with anaerobic production training, 90 min	Match
Thursday	TH training with high-intensity running exercises, 90 min	Individual physical training - low/moderate intensity aerobic training, individual physical needs (a lot playing time/less playing time in yesterday´s match), 45 min
Friday	Tactical/technical TH training, 90 min	Tactical/technical TH training, 90 min
Sunday	Match	Match

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HIGHER RISK OF ACL TEARS IN FEMALE ATHLETES IN GENERAL AND WITH SPECIAL REFERENCE TO HANDBALL

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Summary
There are many reasons why female athletes do have a higher risk of ACL injuries. Main reasons are the anatomical differences between male and female athletes not only in the skeletal structure but also because of their different muscle strengths. Another plausible cause might be the hormonal differences especially the effect of estrogen and gestagen during the female menstrual cycle.

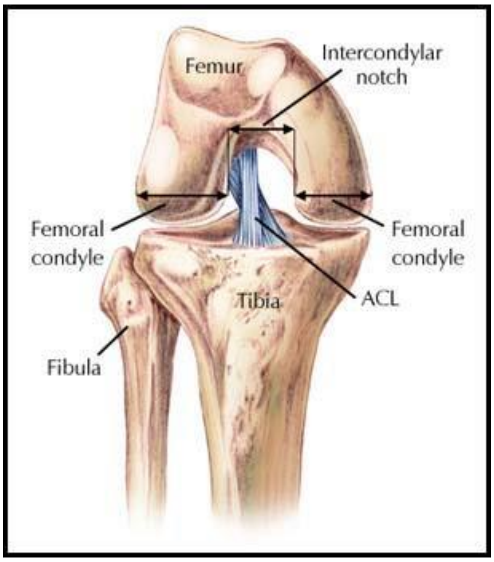
Keywords
Higher risk of ACL ruptures in female athletes, differences in male and female anatomy, hormonal balance.

Introduction
Currently there are more than 2 million registered female handball players worldwide. But despite this number there is surprisingly very little medical literature about female specific sports injuries.

Even though there are many reasons for higher risks of ACL ruptures in female handball players, today I will only focus on the anatomical and physiological gender specific differences.

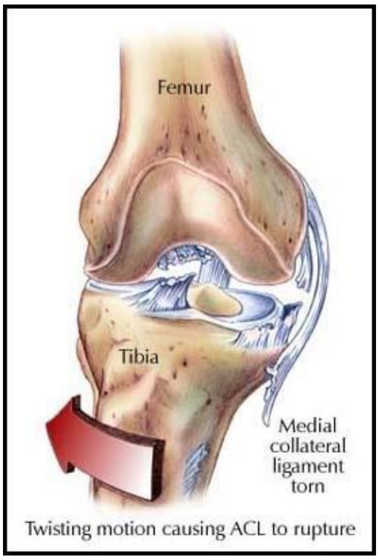
The female anatomy has a higher emphasis on the hull compared to males based on a broader and more elongated pelvic bone structure. Furthermore females have narrow shoulders and limbs that are ~10% shorter than those of males. Based on these facts, it is worth to have a closer and more detailed look at the anatomical differences between male and female athletes.

Discussion



In the knee joint an intercondylar notch (compartment) lies between the two rounded ends of the thigh bone (femoral condyles).

The ACL moves within this notch, connecting the femur (thigh bone) with the tibia (shin bone) and providing stability to the knee. It prevents the tibia from moving too far forward and from rotating too far inward under the femur.



Twisting motion causing ACL to rupture

Women have a narrower notch than men have. Therefore, the space for ACL movement is more limited in women than in men. Within this restricted space, the femoral condyles can more easily pinch the ACL as the knee bends and straightens out, especially during twisting and hyperextension movements. Pinching of the ACL in the joint can lead to its rupture (or tear).

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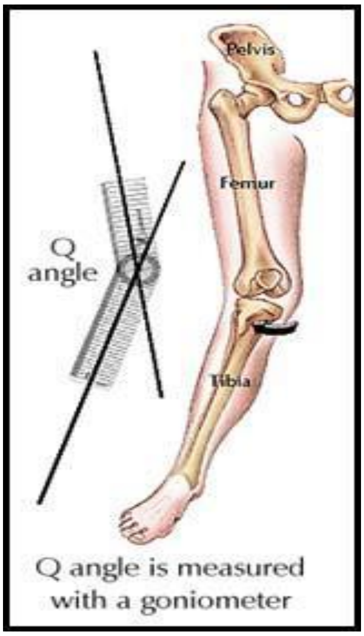

Q angle is measured with a goniometer

In the knee the femur meets the tibia at an angle (called the quadriceps, or Q, angle). The width of the pelvis determines the size of the Q angle. Women have a wider pelvis than men have, therefore, the Q angle is greater in women than in men. At this greater angle, forces are concentrated on the ligament each time the knee twists, increasing the risk of an ACL tear. A twisting injury in a man's knee may only stretch his ACL, however, because of the greater Q angle, the same type of twisting injury in a woman's knee may cause a complete ACL tear.

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Earlier skeletal maturity and an earlier start of puberty are caused by the female estrogen production and thus the reason that the bone structure is about 25% lighter in comparison to the male body. Due to that fact female joints have a higher range of motion and their muscles, tendons as well as ligaments are softer and more flexible. Females have about 1.75 times more body fat than males and their muscles only account for 36% of their total body weight (as opposed to 45% in male bodies) and their overall maximum muscle strength is less compared to men (due to men having more testosterone in their blood).

Female hormones allow for greater flexibility and looseness of muscles, tendons, and ligaments. This looseness helps prevent many injuries because it enables certain joints and muscles to absorb more impact before being damaged. However, this looseness does not necessarily prevent an ACL injury in a woman's knee. If the other ligaments and muscles around the knee are so loose that they cannot absorb the stresses put on them, then even normal loads or forces may be transferred directly to the ACL, making it prone to rupture. In this sense, the ACL not only has to maintain stability of the knee, but it also must make up for instability in a generally loose knee.

When women and men compete in the same sports and at the same levels, they have nearly equal twisting and loading forces placed across their knee joints. However, women have less muscle strength in proportion to bone size than men have. Muscles that help hold the knee in place are stronger in men than in women. Therefore, women rely less on the muscles and more on the ACL to hold the knee in place. Once again, the ACL may have to work overtime making it more prone to rupture. During the menstrual cycle hormone levels vary and may affect knee stability. Recent studies have shown that, at specific points within the menstrual cycle, the knee becomes looser than normal, and ACL rupture is more common.

Traditionally, male athletes participate in twisting sports (such as basketball, football, volleyball, soccer and handball) from a very early age. They develop muscle coordination and reflexes that can protect the knee once they reach a competitive level. These knee reflexes allow strong muscles to control the knee thereby maintaining stability of it. Some female athletes do not participate in the same sports until a later age. Therefore, their muscle strength and coordination, as well as reflexes, may not be as fully developed when they reach a competitive level. The ACL must provide most of the stability in these knees.

Beside these anatomic differences there are also hormonal differences as already mentioned above. Especially and in particular the changes in the hormone balance during the female menstrual cycle. The main representatives are the hormones estrogen and gestagen.

Estrogen causes an increased nutrition and liquid retention within the female body and thus an increase of body weight. It enhances the bone formation and most probably causes an increase in muscle mass, too and it does have manifold psychological effects. **Gestagen** generally increases the basic metabolism as well as an elevation of the body temperature of about 0.5° Celcius. Gestagen also has manifold psychological effects extending as far as depression and anxiety stats.

Despite these thoroughly significant differences there are no higher incidences in injuries between male and female athletes in general. But if we break it down to the different kinds of sport and especially if we take a closer look at Handball, Basketball, Volleyball and Football we realize that female athletes have a higher incident of ACL ruptures.

A comprehensive study of Handball was able to verify that the risk of ACL ruptures in female athletes is 5 times higher than in male athletes. And that risk ratio is also valid amongst youth players. Any one or all of the theories presented here may contribute to the increased number of ACL tears in female athletes.

All in all there are many suggestions and plausible reasons for the higher risk of ACL tears in female athletes but until now not clearly proven and identified causes.
Researchers currently are investigating epidemics of ACL tears in women's sports.

Conclusion:
Until we have more detailed evidence we need to focus on injury prevention from early stages on.

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FORWARD EVER, BACKWARDS NEVER?
CURRENT FINDINGS TO THE RETRACTION BEHAVIOUR IN HANDBALL

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Summary
Defensive retreat behavior in handball has yet to gain scientific attention. To shine light on this crucial part of the game, teams from various age and playing levels of the German Handball Federation were examined. For the purpose of this research, a mixed-method approach was decided. We stipulate that successful defensive retreat behavior could function as a determining performance indicator in handball.

Keywords
retraction behaviour, video analysis, expert-interviews, DHB

Introduction and Research Problem
The focus of this research study lies on the defensive retreat behavior in handball, which has gained in significance since rule changes came into effect in the late 1990s. Particularly, the fast mid-field game forces defending teams to rapidly adjust and organise their defensive formations. Overall handball has changed for the better regarding tactical structure and attractiveness. Prior to the rule changes, teams hardly scored more than 20 points per game. With the rule changes in effect the speed of the game and subsequently the number of goals scored increased dramatically. Furthermore, 40-50 offensive plays used to be common during a particular game, now with the rule changes in effect teams increased these numbers by 50%. These days the popularity of handball comes only second to football in Germany.

The rapid development that the game has undergone, is best illustrated with TBV Lemgos' record season. During the championship season 2002/03 this team nearly perfectioned the counter-attacking game through mid-field. At the time TBV Lemgo was seen as the precursor of the fast break game. During that season TBV scored at least 30 goals in 27 out of 34 league games, and broke 4 times the 40 point barrier. In view of TBVs' success many teams emulate the fast break game. The crowning moment of this development was marked by THW Kiel in 2005 having broken the 50 goal barrier for the first time in a game. Contrasting defensive retreat behavior, the speed of counter attacking has also increased since the 1980s. On average 8-10 goals result from 10-15 counter attack plays in elite male handball. Therefore, from a practical perspective these numbers exemplify the significance defensive retreat behavior may have.

As previously noted, very little research has been published on defensive retreat behavior in handball. Greater weight has been put on counter-attacks against opposing defensive formations *[*e.g. Reisner & Spaeth, 2007, Kolodziej, 2010, Brand, 2008*]*. However, the significance of retreat behavior has been highlighted in Sichelschmidt's article "Der Rückzug ist auf dem Vormarsch" *[*handballtraining, 3/88*]*. His game analysis at the time revealed that „1/4 to 1/3 of all attacks are indeed counter-attacks" *[*Sichelschmidt, 1988, S. 3*]*. Smiatek and Heuer's *[*2012*]* more recent statistical analysis of game results, during the 1997/98 season brought a significant increase in goals scored to light. They concluded that this was brought about by rule changes, which subsequently resulted in a change of attacking strategies. However, no direct link to retreating behavior was drawn. Trosse *[2006]* developed training sequences for retreat behavior. Though these were not built on scientific evidence. Späte *[2008]* provides further insights in „Gegen Tempospiel aktiv verteidigen" about the two-fold tactic school. He analyzed the 2007 world cup to illustrate which tactical solutions were developed in view of the advanced fast-break game. The literature review indicated that no explicit research on retreat behavior has been done, and that at most some observations in that regard have been collected.

Methods

A mixed-method approach was decided on, consisting of expert interviews, as well as qualitative and quantitative game analysis to further explore retreat behavior. Data for this pilot study were collected from five national games, each from respective age and gender groups of participating DHB selection sides. The total number of games observed amounted to 20. Four selection coaches of the German Handball Federation were consulted as experts in semi-structured phone interviews *[*Geertz, 1987; Flick, 2007; Lamnek 1995; Gläser & Laudel, 2006/2010*]*. The resulting interviews were transcribed and content analyzed Mayring, 2000b*]*. Additionally Hansen and Lames' *[2001]* principles of systematic and qualitative game observation, including recurrence and interpretation of observable behavior were drawn upon. Quantitatively pre-structured video sequences of respective retreat behaviors were qualitatively re-analyzed during main analysis. Further aspects of qualitative game analysis were included for this study *[*Dreckmann & Görsdorf, 2006; Dreckmann, Görsdorf & Lames, 2007c*]*.

Results

German men national team

On average the above described retreating behavior of the male national team occurred twelve times per game. A total of 60 counter-attacks during the German national team's five games were observed. This staggering number stands out and underpins the importance organized retreating behavior has for the game. The German team was forced to retreat in that fashion on average every 6 minutes against the Czech Republic and Macedonia. In the game against Serbia this was the case every 4 minutes. Another observation concerned the differentiation at which points during the game retreating formations occurred. No conclusive tendency regarding occurrences over time was noted [fig.2]. On average retreating formations appeared 2.4 times during the first and last third of the second half. However, in comparison to the first half this differs only by 0.2. The least (1.6) retreats occurred during 2/3 of each half. Against the Czech Republic an uneven distribution was noticed. Only 3 of 10 retreats occurred during the second half of the game. In contrast, the game against Sweden produced 3 of 12 retreats in the first half of the game. Of the 37 counter-attacks over five games, goal scoring opportunities were successfully hindered by the German male team.

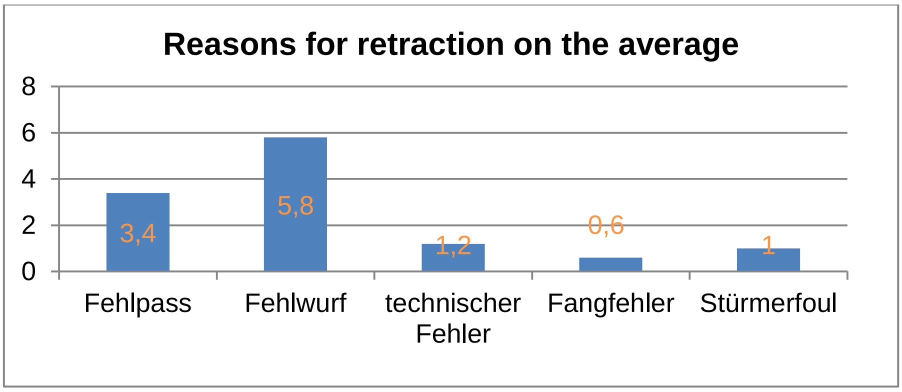

FIG1. *Men: averaged causes for retreats*

Another observation reference is the timing when team start to retreat. For that purpose missed pass, missed throw, technical error, dropped ball and offensive foul were differentiated. Nearly half (29 out of 60) retreats result from missed throws on the opponents goal. Whereas bad passing was only observed 3.4 times. Technical errors, dropped balls or offensive fouls accounted for hardly any the counter attacks in this study. This demonstrates outstanding precision and tactical understanding of the game.

Most of the time, retreats of German players were positional. Once recognizing the new game situation, players retreated in straight lines back to their defensive positions. Out of place wing players returned to their original positions within the opponents half to then retreated in straight lines once having crossed midfield. During immediate counter attacks, the German team fell back on to man-to-man defensive orienting themselves towards the ball, trying to prevent passing opportunities. Once a defensive formation was set up in front of the german goal, players moved with the ball. Several images from observed games examplify the german tactical retreating behavior.

FIG2: *The incoming player from Germany perturbates the attack of Sweden and tries to get the ball with this tactical option.*

A tactical variation of the retreating behavior was observed in several of the analyzed video sequences. The german team substituted “experts”, replacing, during retreat a center-field player with a more defensive oriented player off the bench. Those players then tried to “sneak” up on the ball carrying opposing team (see image below).

Further observations revealed that center-field players do not immediately retreat - remain positioned 6-9 meters off the goal -, but rather aim to interrupt the pass from the goal keeper to one of his players. In such situations these players can slow down fast counter attacks by closing down passing options for the opposing goal keeper. Unnecessary discussion with referees regarding decisions during the offensive plays are prone to lead to mistakes while falling back into retreating formation. This became evident in the game against Poland where one player started arguing with the referee while the remaining team retreated in orderly fashion. Such behavior may result in disadvantageous power plays.

German female national team

In the five games of the german female national team we saw retraction behaviour of this team 65 times. Averagely we have backtrack 13 times per match. In three games the german team has to retract 12 times, the maximum was reached against Montenegro with 16 times.

If we look at the allocation into game-minutes we see that there are frequent retractions in the first ten minutes. By 13 retractions per match there are 3,4 in the early stage of the game. In contrast to this we know that in the closing phase of the game there are 1,2 retractions in average like in the game Germany against Angola. Half of the retractions of the german team, 6 of 12, against China are in the end of the first half.

Moreover in 44 of the altogether 65 retractions a goal against can be prevented by the german team. The german team gets averagely 4,2 goal against them per match in our random sample. Against Island the German team successfully retreated 12 out 13 times conceiving only one goal during that phase of the game.

Of the 65 retreating phases, 42 occurred with interruption of opponents. Resulting on average in 4.6 phases without pressure on opposing teams. Against Norway this was particularly evident, where 3/4 of all fast breaks where pressurised.

The most frequent (23 times) cause for retreating behavior was missed shots on goal. In contrast, on average only 1.6 times missed passes or failed passing on the offensive line resulted in retreats.

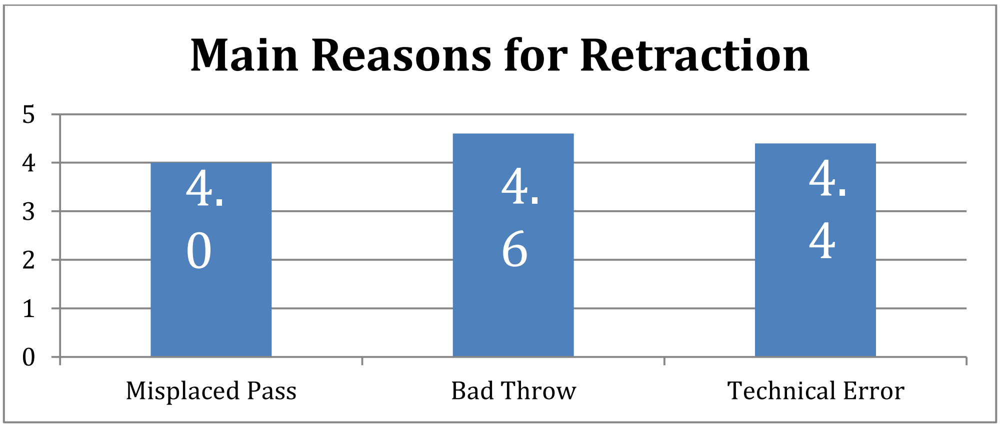

FIG3 *Women: averaged causes for retreats.*

Against China and Angola missed passes and shots amounted to four each. However, against Island missed passes where three times as frequent than missed shots. The originating position of any retreat, with 4.4 times per game is the central backfield.

The occurrence on the RM position stands out in comparison with Montenegro. At that position, a counterattack began six times, while in the right back field this only happened twice, and on all other positions were only affected once. Next to the RM position weaknesses per game were the left backfield (3.6 times) and the right backfield (2.4 times). However, a more frequent mistake on the wing positions are missed passes on the attack lie. Opponents of the women’s team could finish 43% their fast breaks with one or two passes. Island being the exception, where the team was able to cover the field with three passes in 6 of 13 instances.

The kinds of fast breaks, causing the German team to retreat were in most cases second wave counter attacks. Second to this (3.2 times) the German players had to defend against direct counter attacks, and 2.6 times against fast breaks of the first wave. Against Angola four of the counter attacks were halted and continued with a change of pace.

FIG4 *Women: German players running back in the defense nearly in one line.*

All in all, the women selection was in retreat mode over period of 439 seconds. Amounting to 7.2s per phase. Against Angola and Island the shortest phases, at 4s were recorded respectively. With 14s the phase lasted the longest against Norway.

In 20 out of 65 retreats, the original defensive formations were set up before the opposing team could complete their offensive play on goal. Only 10 out of 65 retreats occurred with a positive goal difference. Eleven of these situations arouse from an even point score, while 44 were observed at a negative goal difference.

Conclusions
The focus of this research lay on the analysis of defensive retreat behavior of German elite handball teams, regardless of age, though gender specific. Qualitative and quantitative differences were extracted and put into relation with expert opinions. In the observed male group, fast breaks resulted on average in 4.6 goals/ game, at Junior level 4.2 goals/ game and Juvenile level 2.8 goals/ game. These results illustrate the significance successful retreating formations may have on performance and team outcomes. Insights of this study on retreating behavior should sensitise coaches of all age groups to its potentially game decisive significance. From a scientific perspective a new approach has been brought forward, which should be further scrutinised on grounds of performance analytical aspects.

In view of practise, coaches and experts alike concord that retreating behavior is generally not practised as a separate tactical aspect of the game, but rather as an integral part of the offensive strategy. There exists a lack of specific practise methods, highlighting retreat behavior. Furthermore, experts conclude that retreat behavior consists of more than simply returning to one's own half, but rather taking split second decisions regarding defensive positional shifts in view of the counter attacking opponent. Subsequently, the demand for exclusive practice know how on retreat behavior in handball follows. This particularly the case in view of international competitiveness of German handball.

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FEATURES OF CHANGES OF DIRECTION SPRINT (CDS) PERFORMANCE IN ELITE JAPANESE YOUTH WOMEN HANDBALL PLAYERS: A COMPARISON OF THE CORRELATION COEFFICIENT BETWEEN CDS AND FIELD TESTS

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Summary
The purpose of this study was to clarify the relationship of physical form and field tests to CDS performance in elite Japanese women handball players. A negative correlation was observed among U-18 players between CDS speed and the CDS/SS (Straight Sprint) ratio. However, among U-15 players, no significant correlation was observed between CDS speed and the CDS/SS ratio.

Keywords
handball, changes of direction sprint, women handball players.

Introduction
Movement ability involved in rapidly changing the body's direction is an element of physical strength, which greatly affects the results in team handball. In order to select handball players who can compete at the international level, the Japan Handball Association (JHA) created physical strength tests for young players (2009 National Training System)[1)]. These included the following two items for assessing running ability: the 30 m straight sprint (30mSS) test and the 30 m change of direction sprint (30mCDS) test. The 30mCDS is a measurement item for evaluating CDS performance. Many physical factors are generally known to affect CDS performance. According to Young[2)] and Sheppard[3)], change of direction involves the following three physical factors: technique, leg muscle qualities, and straight sprinting speed. Leg muscle qualities include strength, power, and reactive strength. Based on the findings of previous studies, if there are differences in run-up distance, run-up speed, movement angle, and prediction behaviors when changing direction, the muscular exertion patterns of the lower limbs and their balance with the upper body are predicted to change[4)]. Therefore, in the 30mCDS test conducted by the JHA, clarifying the details of the determining factors of speed is very difficult. First, we determined the relationship between the 30mCDS test, and physical form and jump power. Additionally, we believe that it is possible to obtain findings related to the acquisition of CDS skills according to development level by comparing CDS ability characteristics among various age categories.

The purpose of this study was to clarify the relationship of physical form and field tests to CDS performance in elite Japanese women handball players. We also conducted a comparative analysis of the CDS performance of U-15 and U-18 players.

Objective
Our study sample consisted of 160 Japanese elite women handball players (U-18: 79 and U-15: 81), who participated in the Japan Handball Association's Center Training Program 2010, 2011 and 2012.

Methods

We conducted physical form tests and field tests for all subjects (Center Training Program participants). The field tests included a 30 m straight sprint test (30mSS), 30 m change of direction sprint test (30mCDS), standing jump, and side step. The 30mSS test and 30mCDS test applied a standing starting position with the examinee starting the test at the sound of a whistle. The 30mCDS test involved the examinee sprinting in four straight lines (6 m-9 m-6 m-9 m) with three backward diagonal changes of direction at approximately 130° (Fig. 1).

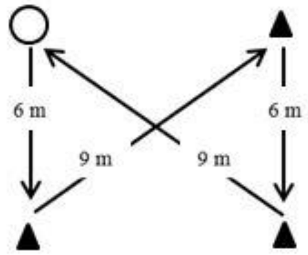


Figure 1 30m changes of direction sprint test

○: Start and Goal, ▲: Turning point

The 30mSS and 30mCDS were evaluated using the time required for completion and average speed (km/h). For standing jump, the examinee jumped forward with both legs from a starting line, and we measured maximum jump distance. For side step, we measured the number of times the examinee stepped over three lines drawn at 1 m intervals in 20 sec. To determine the youth players' relative ability to change direction while running, we calculated the CDS/SS ratio (CDS/SS). CDS/SS is a comparative index of the degree to which 30mCDS prolongs 30mSS. Additionally, we investigated whether there were any relationships between the CDS/SS, sprint speed, standing jump and side step. Statistical differences were analyzed for each correlation between U-18 players and U-15 players.

Statistical analysis

Measurement data were analyzed at the Handball Laboratory at Kagoshima University. All values obtained in this study were represented as mean ± SD. U-18 players' and U-15 players' physical data were compared using unpaired sample t-tests. Relationships between CDS performance and physical data in each age category were examined by calculating Pearson's correlation coefficient. Tests for difference in correlation coefficients were performed when comparing U-18 players and U-15 players.

Results & discussion

Table 1 and Table 2 show the physique index and physical test results for the athlete subjects, respectively. Height and weight were significantly higher in U18 players. U18 players also demonstrated a significantly higher standing jump than U15 players; however, a statistical difference was not confirmed for side steps in both groups.

Table 1 *Physical parameters*

	Height (cm)	Weight (kg)	BMI
U18	168.8 ± 4.6	62.7 ± 6.3	22.0 ± 1.7
U15	166.7 ± 5.1	58.7 ± 6.3	21.1 ± 2.1
U18 vs U15	**	**	**

$**p<0.01$

The mean speeds in the 30mSS test for the U-18 players and U-15 players were 20.74 ± 0.12 km/h and 20.56 ± 0.15 km/h, respectively, and no statistically significant differences were observed between these 2 groups. The mean speeds in the 30mCDS test for the U-18 players and U-15 players were 14.94 ± 0.09 km/h and 14.47 ± 0.08 km/h, respectively. In this test, the U-18 players were significantly faster than the U-15 players ($p<0.01$).

Table 2 *Physical tests*

	30mSS (sec.) (mean km/h)	30mCDS (sec.) (mean km/h)	Standing jump (cm)	Side step (freq.)
U18	5.22 ± 0.28 (20.74 ± 0.12)	7.25 ± 0.39 (14.94 ± 0.09)	209.7 ± 19.0	59.7 ± 4.7
U15	5.28 ± 0.34 (20.56 ± 0.15)	7.48 ± 0.38 (14.47 ± 0.08)	204.4 ± 12.4	59.6 ± 5.0
U18 vs U15	*n.s.*	**	*	*n.s.*

**p<0.01, *p<0.05

A significant correlation was observed between 30mSS and standing jump in both groups (U18: r= 0.534, U15: r=0.528). Greater jump power indicated faster average speeds during the 30mSS. On the other hand, if we focus on the average 30mCDS speed, a decreasing trend for 30mCDS speeds was observed, particularly in U18 players with larger physiques. Interestingly, a significant correlation was not observed between 30mCDS and side step or standing jump in U18 players; however, a significant correlation was observed between 30mCDS and standing jump in U15 players (r=0.312, $p<0.01$). Thus, a higher leg muscle power indicates higher CDS values in U15 players, but this relationship is less likely in U18 players. Although the methods for the direction-changing test differ, Peterson[6)] have demonstrated a high degree of relationship between CDS and horizontal jump power.

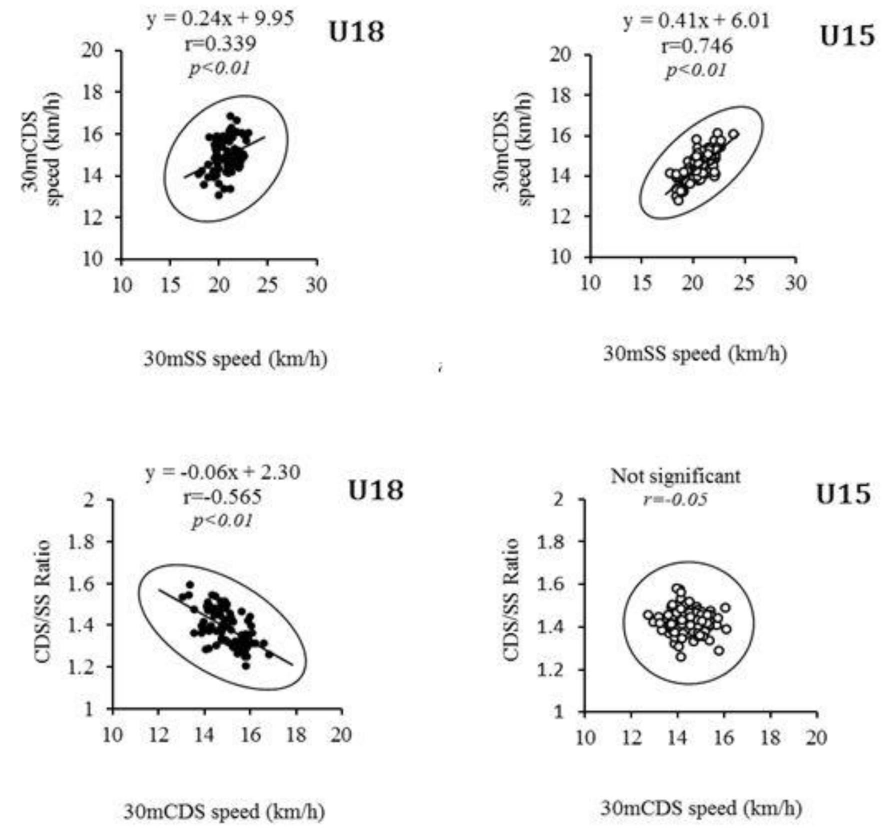
Table 3 *Correlation coefficients between Parameters*

		30mSS k/h	30mCDS k/h
U18	Height	-0.229 (*)	-0.427 (**)
	Weight	-0.143 (n.s.)	-0.435 (**)
U15	Height	-0.358 (**)	-0.229 (*)
	Weight	-0.234 (*)	-0.200 (n.s.)

		Standing jump	Side step
U18	30mSS#	0.534 (**)	0.303 (**)
	30mCDS#	0.108 (n.s.)	0.020 (n.s.)
U15	30mSS#	0.528 (**)	0.051 (n.s.)
	30mCDS#	0.312 (**)	0.295 (**)

#: k/h **p<0.01, *p<0.05

CDS/SSs for the U-18 and U-15 players were 1.39 ± 0.01 and 1.42 ± 0.01, respectively, and the U-15 players displayed a significantly higher rate of delay when changing direction ($p<0.05$). The U-18 players displayed a moderately strong correlation between SS speed and CDS speed (r=0.339), while the U-15 players displayed a very strong correlation (r=0.746). A comparison of the correlation between SS speed and CDS speed for the 2 groups showed a significantly higher correlation for the U-15 players than for the U-18 players ($p<0.01$). These results showed that U-15 players who are fast during straight sprints are also fast during change of direction sprints, with a stronger SS speed to CDS speed correlation than U-18 players (Figs. 2).



A positive correlation was observed among U-18 players between SS speed and CDS/SS; as SS speed increased, CDS/SS also increased (r=0.583, *p<0.01*). A significant positive correlation between SS speed and CDS/SS was also observed among U-15 players (r=0.623, *p<0.01*). However, no significant difference was observed for these correlations between the 2 groups. A negative correlation was observed among U-18 players between CDS speed and the CDS/SS; as CDS speed increased, the CDS/SS decreased (*p<0.01*). However, among U-15 players, no significant correlation was observed between CDS speed and the CDS/SS ratio (Figs. 3). The above results showed that both U-18 players and U-15 players with high SS speed tend to have a high CDS/SS ratio. This was considered to result largely from the delay in change of direction caused by inertial force when turning. However, U-18 players displayed a strong correlation between CDS speed and the CDS/SS ratio. From these results, it was inferred that the acquisition of turning skills improved U-18 players' deceleration and reacceleration abilities when turning.

Conclusion

The CDS test, administered by the JHA to elite women handball players, is likely to be the same test for U15 players to test agility functions such as run speed and leg muscle power. Furthermore, in U18 players, not only speed and muscle power but also turning skills are thought to influence CDS ability. These results are consistent with and support the model proposed by Young. Thus, by gathering CDS test results from elite women handball players and performing statistical analysis, we believe that it could be a useful tool to assess physical and technical developmental criteria for handball athletes.

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ANTHROPOMETRIC AND PHYSICAL PERFORMANCE CHARACTERISTICS OF ELITE AND NON-ELITE YOUTH FEMALE TEAM HANDBALL PLAYERS

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Summary
An examination of the anthropometric and physical characteristics of British (non-elite) and elite European female youth team handball players. Findings reveal that British players compare unfavourably to elite European players in a variety of anthropometric and performance characteristics. Such studies are useful for emerging team handball nations in designing appropriate training strategies and to improve talent identification processes.

Keywords
talent identification, testing, kinanthropometry, standard

Introduction
Team handball is an intermittent team sport, characterised by high-intensity explosive movements such as sprints, jumps, throws, and physical collisions, which are interspersed with periods of low intensity activity such as standing, walking, and jogging (Michalsik, Aagaard, & Madsen, 2012; P*ó*voas et al 2012). Success in team handball is determined by a variety of technical and tactical, anthropometric, and physical performance characteristics (Vila et al., 2012). Although the measurement of technical and tactical skill are often confounded by subjectivity, assessment for anthropometric and physical profiles enable the collection of objective data, which can be used to form structured talent detection and identification programmes (Bloomfield, Ackland, & Elliot, 1994).

Information on the essential characteristics for successful team handball performance is particularly valuable to coaches and practitioners working with developing nations or federations, where there are a limited number of athletes to select from and the sport is not well established (Mohamed et al., 2009). From a relatively unknown sport in Great Britain prior to the 2012 Olympic Games, there has been a 96% increase in affiliated club members from 2010-11 season to 2012-13 season. These data are accompanied by an overall increase in participation at the youth level National School Cup, particularly for U15 age category players (48%; EHA, personal correspondence). Despite the increase in club-level and school participation, performance at youth international standard remains poor. Indeed, in recent competition the female U16 team won only one out of five games to place last in their group category, while the U19 team did not qualify for the European Championships. Therefore, in order to maximise the potential for success, it is important for such nations to develop superior systems to identify and develop talent, which requires comprehensive and up-to-date normative values on elite players (Carter, Ackland, Kerr, & Stapff, 2005). Using these values as a reference, coaches and practitioners can then select players based on an elite prototype, which determines those physically capable of achieving success in a particular sport or position within that sport (Vila et al., 2012).

Differences in anthropometric and performance characteristics between playing standards are widely available for male team handball players (Matthys et al., 2011; Mohamed et al., 2009; Zapartidis, Vareltzis, Gouvali, & Kororos, 2009a; Gorostiaga, Granados, Ibáñez, & Izquierdo, 2005), but are less so in females (Zapartidis et al., 2009a; Granados, Izquierdo, Ibáñez, Ruesta, & Gorostiaga, 2007). In particular, there is a dearth of research assessing both anthropometric and performance characteristics of youth female players of different standard. In the one study identified, Zapartidis et al. (2009a) recorded better values for selected Greek national players in ball velocity and standing long jump, but not in 30 m sprint speed, sit and reach or $\dot{V}O_2$ max. Selected players were also taller, and had greater arm spans than non-selected players, but were similar in body mass, body mass index (BMI), hand length, and hand-spread. However, this study assessed very young players (~13 y) and only provides information from one nation.

Therefore, this study aimed to examine the differences in performance and anthropometry between non-elite and elite female team handball players. Such data would be useful to both developing and elite nations who wish to gain more information on the key features required to be successful in youth female team handball.

Methods

Participants

In total, 125 female team handball players (16.07 ± 1.3 y) were recruited to take part in the investigation. This consisted of 52 players from England who were placed in the non-elite group (15.68 ± 1.27 y), and 73 players from high standard European nations who were placed in the elite group (16.36 ± 1.34 y). Countries were considered to be elite handball nations as a result of their success at the two major youth team handball competitions, the European Handball Federation (EHF) European Women's U-17 Handball Championships and the Women's Youth World Championships. From the elite nations invited to take part in the study (n = 6), teams from Denmark, Norway and Spain confirmed their interest. These nations consistently placed within the top five teams at the aforementioned tournaments, whereas Great Britain or England had never qualified to compete.

All elite players competed for their club (n = 70), of whom 29 competed at national level (U17- U19). Of the remaining elite players who did not compete for their national team (n = 41), 24 competed in the highest league for their age category (Denmark: Liga and qualified for the Danish championship; Norway: Bring series), and 17 competed in the second highest league (Spanish Catalan league). Of the non-elite players, all competed for their club (n = 52), of whom 29 represented Great Britain and/ or England (U16 – U19). All measurements were taken 'in-season' between December 2012 and June 2013 over a 2-3 day period. After completion of anthropometric measurements, all performance tests were completed in one day in the same order for each group of participants. All players provided written informed consent and the study was approved by the University of Chester, Faculty of Applied Health Sciences Research Ethics Committee.

Procedures

Anthropometric characteristics

Participants were measured for standing stature (Seca, Leicester Height Measure, Hamburg, Germany) to the nearest 0.1 cm, body mass (Tanita, BWB-800, Tanita Corporation, Tokyo, Japan), to the nearest 0.1 kg, eight skinfolds (Harpenden, British Indicators, Burgess Hill, UK) to the nearest 0.1 mm, five girths (Lufkin Executive Thinline, W606PM, USA) and two breadths (Roscraft Campbell 10, Canada) to the nearest 0.1 cm, according to the protocols outlined by the International Society for the Advancement of Kinanthropometry (ISAK; Marfell-Jones, Olds, Stewart, & Carter, 2006). Skinfold sites were landmarked using standard ISAK procedures at: the triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh, and medial calf on the right side of the participant's body. All sites were identified and then measured using Harpenden callipers with 10 $g{\cdot}mm^{-2}$ constant pressure.

Girths were measured using a Lufkin metal tape for the forearm (relaxed and flexed/ tensed), waist, hips (gluteal), and calf. Breadths were measured using a Rosscraft Campbell 10 (18 cm) small bone caliper for the humerus and femur. Participants wore shorts and training bra for all anthropoemtric measurements.

Physical performance tests
All participants completed the same tests in the following order: maximal counter-movement jump test (CMJ), 20 m sprint test with 10 m split, shooting velocity, repeated shuttle sprint and jump ability test (RSSJA) and the Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1). Participants were provided with immediate feedback throughout procedures for motivational purposes and were given adequate recovery between each test to limit any effect of cumulative fatigue.

Results
Analysis revealed significant differences between non-elite and elite players in a variety of anthropometric (Table 1) and performance (Table 2) characteristics. Elite players were significantly taller and had higher body mass than their non-elite counterparts (both $P < 0.001$). Furthermore, elite players had greater breadth and girth measurements than non-elite players ($P < 0.05$) and scored lower in three out of eight skinfold measurements ($P < 0.05$). However, there were no differences in the total sum of six or eight skinfolds ($P > 0.05$), or waist-to-hip ratio between standards ($P > 0.05$). Somatotype profile for non-elite players was mesomorphic endomorph (4.0 – 3.4 – 2.3), whereas elite players were classified as central (3.6 – 3.3 – 2.6). In both cases, endomorphy was the most dominant component, with ectomorphy being the least dominant. Somatotype attitudinal distance was 1.04 and there were no difference in somatotype attitudinal mean (SAM) between groups. Out of all performance variables tested, only maximal CMJ height was not significantly different between groups ($P > 0.05$).

Discussion
This is the first study to include detailed analysis on both anthropometric and performance characteristics on a large sample of female players representing elite and non-elite team handball nations. The aim of this study was to examine the differences in anthropometry and performance between non-elite and elite youth female team handball players. These findings improve understanding of the quintessential characteristics needed to achieve excellence, so that selection and training practices can be modelled accordingly.

Key findings of this study revealed a vast disparity in anthropometric and performance characteristics between non-elite and elite team handball players, with 64% of all anthropometric variables and 93% of all performance variables showing significant differences between standards. Clearly there is a favourable anthropometric and performance profile for players competing at an elite level, which may be instrumental to aid the development of smaller team handball nations.

Elite players were on average ~8 cm taller than non-elite players in this study, which was mostly attributed to greater statures in wing and pivot positions. Our findings are similar to the differences (~9 cm) reported by Granados et al. (2007) when comparing adult amateur and elite Spanish females and between non-elite and elite Greek youth (Mohamed et al., 2009; Zapartidis et al., 2009a) and adult males (Hasan et al., 2007; Bayios et al., 2006).

Table 1. *Anthropometric characteristics of non-elite and elite players.*

Variable	**Non-elite (*n* =44)**	**Elite (*n* =73)**	***F***	***P***	**Effect size *(d)***
Age (y)	15.66 ± 1.19	16.36 ± 1.34			
Body mass (kg)	61.07 ± 7.68	67.07 ± 9.78	12.246	<0.001*	-0.68
Stature (m)	1.65 ± 0.58	1.72 ± 0.73	27.160	<0.001*	-0.12
Skinfolds (mm)					
Sum of 6	94.78 ± 21.59	88.51 ± 20.71	2.44	0.121	0.30
Sum of 8	118.68 ± 26.53	111.28 ± 26.57	2.13	0.147	0.28
Girths (cm)					
Arm relaxed	26.33 ± 2.13	27.78 ± 2.66	9.43	0.03*	-0.60
Corrected arm	24.82 ± 1.92	26.26 ± 2.50	10.769	0.001*	-0.65
Arm flexed	27.28 ± 2.23	29.3 ± 2.38	20.609	<0.001*	-0.88
Waist	70.13 ± 5.53	72.95 ± 5.20	7.696	0.006*	-0.53
Gluteal	95.94 ± 5.56	99.38 ± 6.41	8.702	0.004*	-0.57
Calf	35.04 ± 2.29	35.94 ± 2.36	4.055	0.046*	-0.39
Corrected calf	33.49 ± 2.16	34.39 ± 2.25	4.515	0.036*	-0.41
Waist-to-hip ratio	0.73 ± 0.04	0.73 ± 0.03	0.303	0.583	
Breaths (cm)					
Humerus	6.38 ± 0.28	6.53 ± 0.32	6.745	0.011*	-0.50
Femur	8.02 ± 0.41	8.19 ± 0.42	4.512	0.036*	-0.41
Somatotype					
Endomorph	4.03 ± 1.09	3.64 ± 1.0	3.786	0.054	0.37
Mesomorph	3.37 ± 1.16	3.25 ± 0.88	0.420	0.518	0.17
Ectomorph	2.34 ± 1.16	2.61 ± 1.09	1.665	0.20	-0.24
SAM	0.00 ± 0.02	-0.01 ± 0.01	0.00	0.984	0.32

Note: * significance at $P < 0.05$

Table 2. *Performance characteristics of non-elite and elite players.*

Variable	**Non-elite (*n* =47)**	**Elite (*n* =66)**	***F***	***P***	**Effect size *(d)***
Age (y)	15.60 ± 1.19	16.29 ± 1.22			
Sprints and CMJ					
10 m sprint (s)	2.10 ± 0.13	2.05 ± 0.08	6.803	0.01*	0.46
20 m sprint (s)	3.65 ± 0.23	3.5 ± 0.19	13.583	<0.001*	0.71
CMJ height (cm)	28.19 ± 5.42	29.58 ± 5.58	1.749	0.189	-0.25
CMJ power (W)	2306.53 ± 545.83	2789.19 ± 607.82	17.495	<0.001*	-0.84
Shooting velocity ($km{\cdot}h^{-1}$)					
Penalty	62.59 ± 7.87	72.29 ± 10.70	76.777	<0.001*	-1.72
9 m running	60.70 ± 8.74	77.10 ± 8.67	96.229	<0.001*	-1.88
9 m running jump	59.88 ± 8.50	75.29 ± 8.34	90.199	<0.001*	-1.83
Intermittent endurance					
Yo-Yo IR1 distance (m)	906 ± 324	1270 ± 515	18.068	<0.001*	-0.85
RSSJA					
10 m average (s)	2.42 ± 0.15	2.34 ± 0.12	9.132	0.003*	0.59
Agility average (s)	1.56 ± 0.28	1.38 ± 0.32	9.850	0.002*	0.60
25 m average (s)	6.24 ± 0.33	5.95 ± 0.37	16.984	<0.001*	0.83
25 m decrement (%)	5.02 ± 2.49	3.96 ± 2.06	5.977	0.016*	0.46
Average CMJ (cm)	21.09 ± 4.87	24.65 ± 5.10	13.649	<0.001*	-0.71
CMJ decrement (%)	14.76 ± 12.4	8.03 ± 4.68	15.621	<0.001*	0.72
CMJ average power (W)	2010.08 ± 493.13	2405.98 ± 646.65	11.137	0.001*	-0.69

Note: * significance at $P < 0.05$

Our non-elite players (~1.65 m) were comparable to Greek national players aged ~14 years (1.63 m – 1.66 m, Zapartidis et al., 2009a, 2009b) but shorter than national Norwegian females aged 16-18 years (~1.69 m – 1.70 m; Ingebrigtsen et al., 2012). Interestingly, non-elite players from this study had similar statures to the English average for 16-24 years (1.64 m, Health Survey for England, 2010), which is in contrast to elite female team handball players who tend to be taller than their national average (Ingebrigtsen et al., 2013; Zapartidis et al., 2009b). Elite players from this study were taller (~1.72 m), also surpassing statures reported for some (~1.71 m; Vila et al., 2012; ~1.66 Bayios et al., 2006; ~1.69 m; Milanese et al., 2011), but not all (~1.75 m Granados et al., 2007; ~1.76 - 1.79 m Ronglan et al., 2006) elite adult females. Collectively, these data confirm that above average stature is a key physical requisite for elite female handball players.

Body mass for elite players was ~7 kg greater than non-elite players (~61 kg c.f. 67 kg). While not statistically significant, this is similar to the ~5 kg difference reported for sub-elite and elite Spanish female players (Granados et al., 2007), youth (Mohamed et al., 2009) and adult males (Bayios et al., 2006). However, our findings are in contrast to those of Milanese et al. (2011), who reported no difference in body mass between standard in adult females. Referring to the limited data available for youth females, both non-elite and elite players from this study were heavier than top league and national youth Greek players (~57 kg, Zapartidis et al., 2009a, 2009b), whereas elite Norwegian females (~59 - 63 kg, Ingebrigtsen et al., 2013) shared greater similarity to non-elite players from this study. As our study represented a large sample of elite players from three of the best team handball nations, these data might highlight the increasing tendency for youth players to be heavier in in the modern game. Moreover, elite players from this study shared greater similarity with elite adult females (67 kg – 69 kg: Vila et al., 2012; Milanese et al., 2011; Granados et al., 2007), suggesting that higher body mass in youth players is preferable. The finding that elite youth players exhibit similar stature and body mass to adult players confirm that these characteristics are paramount when selecting and modelling players at a young age.

Findings do not concur with those of previous studies who have reported lower body fat and higher fat-free mass for players of better standard (Milanese et al., 2011; Hasan et al., 2007; Bayios et al., 2006; Granados et al., 2007; Gorostiaga et al., 2005). Notwithstanding, different methods for assessing body fat and the problems associated with equation-related percentage estimation used in other investigations, these data suggest that body fat does not differ between elite and non-elite female team handball player.

Performance markers

The differences between non-elite and elite players observed in this study, accompanied by moderate to large effect sizes for the majority of handball specific performance variables, re-affirms the importance of a multitude of characteristics for youth female competition.

There was a large and significant difference in throwing velocity between non-elite and elite players in every position. Accordingly, these findings suggest that improved throwing velocity is a requirement of all youth players from Great Britain to be able to compete at a higher standard. Indeed, the final outcome of the match is dependent on the team scoring the most goals, requiring players to execute shots with greatest velocity to beat the goalkeeper (Zapartidis et al., 2009c; Gorostiaga et al., 2005). Research has shown greater standing and three-step running handball shooting velocities for elite players when compared to their amateur counterparts (Wagner et al., 2012; Wagner et al., 2010; Granados et al., 2007; Gorostiaga et al., 2005).

The ability to sprint and change direction at high velocities is an important determinant of team handball performance due to the continuous need to reposition oneself during transition between phases of attack and defence (Póvoas et al 2012; Michalsik et al., 2013; Buchheit et al., 2010). This study observed that maximal sprinting performance discriminated between elite and non-elite players, with positional analysis revealing that elite backs and pivot position players exhibited superior sprint performance over 20 m compared to their non-elite counterparts. These findings are similar to previous studies that have observed differences in 30 m sprint time for youth males (Zapartidis et al., 2009a), and the 2 - 3% difference in 5 m and 15 m speed between elite and amateur females (Granados et al., 2007). Elite players also performed better than non-elite players on all variables of the RSSJA (with moderate and large effect sizes), showing that this test encompassing speed, agility and jumping characteristics may prove useful when testing a large number of players for a range of physical skills during selection processes. Results from this study confirm the findings of Buchheit and colleagues (2010), however more studies using this test in both youth and adult players are needed to provide comparative data.

Intermittent endurance performance (Yo-Yo IR1) also discriminated between non-elite and elite players, and support findings reported by Matthys and colleagues (2011). In particular, non-elite wings and pivot position players performed significantly worse than their elite counterparts in this test, suggesting that coaches from Great Britain should seek to improve aerobic intermittent capacity more so for these positions, or select players who score higher on this test. Although research in adult players does not support the need for high aerobic capacity (Ziv & Lidor, 2009; Gorostiaga et al., 2009), studies have used different methods with questionable applicability to the discontinuous high-intensity nature of team handball performance. Therefore, these results promote the use of the Yo-Yo IR1 test to distinguish between elite and non-elite youth players, and provide the first normative values to be used by coaches and practitioners to inform selection and practice in youth females.

Jump height during the CMJ was the only performance variable that did not differ between non-elite and elite players. This observation is interesting given the important role of jumping in various aspects of the game, such as shooting and blocking (Buchheit et al., 2010). Despite this, our results agreed with other studies failing to find differences in vertical jump performance between elite and amateur males (Gorostiaga et al., 2005), and between elite and amateur females (CMJ with swinging arms; Granados et al., 2007).

In conclusion, this study indicated a large disparity between non-elite and elite youth female team handball players for both anthropometric and performance characteristics. As such, these data provide normative values to be used by coaches. However, it is appreciated that successful team handball players are required to encompass a multitude of physical, technical, tactical and psychological skills, and research would benefit from more studies taking a combined approach to ascertain the most important determinants of successful team handball performance.

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SPRINT PERFORMANCE AND ANAEROBIC POWER IN ADOLESCENT FEMALE TEAM HANDBALL PLAYERS

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Summary
Performance in Team Handball (TH) includes many fast high-intensity activities (e.g. sprinting, jumping, shooting, blocking) taxing mainly the anaerobic metabolic energy transfer system, which can be assessed either in laboratory or in a field setting. The aim of this study was to examine the relationship between widely used assessment methods in exercise testing: 5 m, 10 m and 20 m sprint test, and laboratory methods: a series of jump tests, handgrip strength test and Wingate anaerobic test (WAnT). Eleven adolescent female TH players (age 13.8±1.1 years, weight 56.5±7.3 kg, height 159.9±4.0 cm, body fat percentage 24.7±4.4%) performed the abovementioned anaerobic tests. The correlations of 5 m, 10 m and 20 m sprint with peak power of WAnT were -0.44 ($p=0.171$), -0.63 ($p=0.036$) and -0.82 ($p=0.002$), respectively; with CMJ -0.68 ($p=0.022$), -0.73 ($p=0.011$) and -0.42 ($p=0.202$); and with Bosco test -0.66 ($p=0.028$), -0.78 ($p=0.005$) and -0.59 ($p=0.054$). Despite the small sample of participants in this study, the correlations between sprint tests and most of the anaerobic power tests were moderate to very large, suggesting the further use of laboratory methods in TH. In addition, we observed that the magnitude of these correlations was dependent on the sprint distance, i.e., the highest correlations of jumping tests were noticed in 5 m and 10 m sprints, while the highest correlation of peak power of WAnT was in 20 m. Based on these findings, it was concluded that laboratory methods can be informative about a TH player's sprint ability; however, this relationship varies according to sprint distance.

Keywords
women, athletes, running, Wingate test, jumping.

Introduction
Performance in Team Handball (TH) includes many fast high-intensity activities (e.g. sprinting, jumping, shooting, blocking) taxing mainly the anaerobic metabolic energy transfer system, which can be assessed either in laboratory or in a field setting. Recent research has revealed that anaerobic power, assessed by short-term cycling and jumping tests, discriminates between TH elite clubs with different ranking (11). On the other hand, a sprint test of short distance (e.g. from 5 m to 30 m) is widely used as a part of a physical fitness battery (4-7, 9, 10, 12, 14, 15).

A fundamental question that arises with regard to the physical fitness assessment is whether laboratory and field tests can be used interchangeably. Therefore, the aim of this study was to examine the relationship between the widely used assessment methods in field testing (5 m, 10 m and 20 m sprint test) and laboratory methods (isometric strength, jumping and cycling tests).

Methods
For the purpose of this study, 11 adolescent female TH players (age 13.8±1.1 years, weight 56.5±7.3 kg, height 159.9±4.0 cm, body fat percentage 24.7±4.4%), members of a national

level club's academy, volunteered to participate (**Table 1**). Weight was measured with an electronic weight scale (HD-351 Tanita, Illinois, USA) in the nearest 0.1 kg and height with a portable stadiometer (SECA, Leicester, UK) in the nearest 1 mm with participants being barefoot and in minimal clothing. Body mass index was calculated as the quotient of body mass (kg) to height squared (m^2). A caliper (Harpenden, West Sussex, UK) measured skinfolds (0.5 mm) and body fat percentage was calculated from the sum of 10 skinfolds.

In the handgrip strength test (HST), the participants were asked to stand with their elbow bent at approximately 90˚ and instructed to squeeze the handle of the handgrip dynamometer (Takei, Tokyo, Japan) as hard as possible for 5 seconds (1). HST was calculated as the sum of the best efforts for each hand. In addition, this sum was divided by body mass and expressed as $kg \cdot kg^{-1}$ of body mass in order to provide relative strength.

The Wingate anaerobic test (WAnT) (3) was performed in a cycle ergometer (Ergomedics 874 Monark, Varberg, Sweden). Briefly, participants were asked to pedal as fast as possible for 30 s against a braking force that was determined by the product of body mass in kg by 0.075. Mean power (Pmean) was calculated as the average power during the 30 s period and was expressed as $W \cdot kg^{-1}$.

The participants performed two trials for each jumping exercise (SJ, CMJ and CMJa) and the best result was recorded (2). Height of each jump was estimated using the Opto-jump (Microgate Engineering, Bolzano, Italy), and was expressed in cm. Bosco test was conducted on the same equipment as the abovementioned jump test. The participants were instructed to jump as high as possible, while trying to retain short ground contact times (13). They were also requested to keep their hands on their waist throughout the test. The mean power during the 30 s test was recorded in $W \cdot kg^{-1}$.

The participants performed 5 m, 10 m and 20 m sprint twice with a break of 5 min, and their best trial was recorded. Each sprint was timed using a photocell system (Brower Timing Systems, Utah, USA). We used two pairs of photocells, set at 0 m and the end of the respective distance. The photocells were placed at the belt height in order the legs not to break the light beam according to manufacturer's guidelines and the participants started their attempts from a standing position 0.5 m behind the first pair of photocells.

Statistical analyses were performed using IBM SPSS v.20.0 (SPSS, Chicago, USA). Data were expressed as mean and standard deviations of the mean (SD). Using the 'median split' technique, the participants were divided into two groups ("Fast" and "Slow") according to the median in the 20 m sprint test. Independent student t-test was used to examine differences between these groups. The relationship between the aforementioned tests was examined using Pearson's product moment correlation coefficient (r). Magnitude of correlation coefficients were considered as trivial ($r< 0.1$), small ($0.1< r <0.3$) moderate ($0.3< r <0.5$), large ($0.5< r <0.7$), very large ($0.7< r <0.9$) and nearly perfect ($r>0.9$) and perfect ($r=1$) (88). The level of significance was set at $\alpha=.05$.

Results

The comparison between "fast" and "slow" players revealed better scores in the former players for most of the characteristics under examination. In their anthropometry, we did not find any statistically significant difference. With regard to peak power and mean power of WAnT, "fast" players had superior performance than their "slow" counterparts either when these indices were expressed in absolute (W) or relative to body mass values ($W.kg^{-1}$). The findings in the force-velocity test, handgrip strength test and the jumping tests were in the same direction: better scores or indication for better performance in the "fast" players.

Table 1. *Physical characteristics of "fast" and "slow" players.*

	"Fast" players (n=5)	"Slow" players (n=5)
Anthropometry		
Age (yr)	14.0 (1.2)	13.8 (1.2)
Body mass (kg)	57.3 (4.2)	54.1 (9.6)
Height (cm)	161.6 (3.2)	157.6 (4.0)
BMI ($kg·m^{-2}$)	21.9 (1.3)	21.7 (3.0)
BF (%)	24.3 (4.8)	24.6 (5.0)
FFM (kg)	43.2 (1.8)	40.5 (5.3)
Sprint tests		
20 m sprint (s)	3.70 (0.08)	3.98 (0.08)‡
10 m sprint (s)	2.09 (0.07)	2.22 (0.11)
5 m sprint (s)	1.20 (0.05)	1.28 (0.10)
Wingate anaerobic test		
Ppeak (W)	514 (48)	399 (57)†
Ppeak ($W.kg^{-1}$)	8.98 (0.73)	7.42 (0.46)†
Pmean (W)	384 (37)	297 (43)*
Pmean ($W.kg^{-1}$)	6.70 (0.48)	5.53 (0.52)*
Force-velocity test		
Pmax (W)	636 (79)	482 (93)*
Pmax ($W.kg^{-1}$)	11.2 (1.7)	9.0 (1.9)
v0 (rpm)	170 (11)	190 (58)
F0 (kg)	15.1 (2.4)	11.3 (4.7)
Handgrip strength test		
HST (kg)	63.1 (7.4)	53.5 (16.6)
HST ($kg·kg^{-1}$)	1.11 (0.15)	0.99 (0.26)
Jumping tests		
SJ (cm)	21.8 (1.9)	19.3 (4.1)
CMJ (cm)	23.3 (1.9)	19.8 (3.3)
CMJa (cm)	27.3 (4.2)	25.2 (5.0)
Bosco Pmean ($W.kg^{-1}$)	25.6 (3.2)	18.4 (4.3)*

BMI=body mass index, BF=body fat percentage, FFM=fat free mass, Ppeak and Pmean=peak and mean power during the Wingate anaerobic test, respectively, Pmax=maximal power output estimated by the Force-velocity test, v0 maximal velocity, F0 maximal breaking force, HST=handgrip strength test, SJ=squat jump, CMJ= countermovement jump, CMJa countermovement jump with arm-swing.

The correlation analysis confirmed the abovementioned findings of the comparison between "fast" and "slow" players. In most of the cases, we observed negative relationship between sprint performance and laboratory measures, i.e., the better the score in a laboratory test, the lowest the time in sprint performance (**Table 2**).

Table 2. *Correlations of sprint performance with laboratory tests.*

	20 m	10 m	5 m
Wingate anaerobic test			
Ppeak (W)	-0.63*	-0.42	-0.26
Ppeak ($W.kg^{-1}$)	-0.82†	-0.63*	-0.44
Pmean (W)	-0.53	-0.43	-0.27
Pmean ($W.kg^{-1}$)	-0.66*	-0.69*	-0.51
Force-velocity test			
Pmax (W)	-0.58	-0.20	-0.18
Pmax ($W.kg^{-1}$)	-0.49	-0.17	-0.18
v0 (rpm)	0.25	-0.35	-0.26
F0 (kg)	-0.43	0.09	0.02
Handgrip strength test			
HST (kg)	-0.27	-0.46	-0.28
HST ($kg{\cdot}kg^{-1}$)	-0.22	-0.61*	-0.45
Jumping tests			
SJ (cm)	-0.20	-0.63*	-0.57
CMJ (cm)	-0.42	-0.73*	-0.68*
CMJa (cm)	-0.26	-0.57	-0.43
Bosco Pmean ($W.kg^{-1}$)	-0.59	-0.78†	-0.66*

Ppeak and Pmean=peak and mean power during the Wingate anaerobic test, respectively, Pmax=maximal power output estimated by the Force-velocity test, v0 maximal velocity, F0 maximal breaking force, HST=handgrip strength test, SJ=squat jump, CMJ= countermovement jump, CMJa countermovement jump with arm-swing.

Conclusions

Based on these findings, it was concluded that laboratory methods can be informative about a TH player's sprint ability; however, this relationship varies according to sprint distance.

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NEED AND PROPOSAL FOR CHANGE IN THE SIZE OF WOMEN'S HANDBALL BALL SUPPORTED BY A SCIENTIFIC STUDY: 'THE COVERAGE INDEX OF THE BALL'

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Summary
The present study collected and analyzed data from 1612 handball players (779 women and 833 men) from 13-14 up to more than 18 years old. We collected data of 3 linear measurements of players' s dominant hand, and using a new formula we obtained the "ball coverage index" which indicates the % of ball that a hand is able to cover. Finally, we propose, in a scientific way, the measure of ball that should have each age category in order to be proportional between men and women

Keywords:
Team handball, women handball, size of ball, hand's measurement, ball coverage index

Introduction
The intention of this study is to analyze and determine if the game official balls according to the article 3: the ball, of the Rules of the game (International Handball Federation, 2011), are proportionate, among men and women, depending on the measure of their hands, and more specifically, whether our findings on what we have called "ball coverage index, Porras, Oliver and Sosa"[1] of the dominant hand, is proportional between women and men in the same age category.

Different authors (Antón, 1990; Bárcenas, 1976; Bárcenas & Román, 1991; Enríquez & Falkowski, 1982; Oliver & Sosa, 1996; Torres, 1991) indicate the importance of adapting the ball properly to perform subsequent actions such as pass or shoot, with guarantees of success. Llorente and Díez (1996) remark that is very important to adapt correctly the ball in the introduction of handball at school. From the earliest references (Bayer, 1978, 1983; Czerwinski, 1977, 1984; Firan & Massano, 1973; Ghermanescu, 1979; Goluch, 1982; Marz, 1967; Müller & Baier, 1975; Singer, 1978; Taborsky, 1993; Vick, 1979) have been highlighted the importance of adapting the ball with safety. Furthermore, numerous studies exist, cited by Molina (2010), where are measured different segments of the body, including hands, with the aim of players detection (Antón, 1990; Ávila, 1997; Cercel, 1980, 1990; Czerwinski, Rouba, & Aguilá, 1993; Laguna y Torrescusa, 2000; Román, 1994; Trosse, 1984, 1993).

But despite the importance of this topic, were found only studies of the authors (Oliver, 2000; Oliver & Sosa, 2011a, 2011b) that deal the relation between the measures of handball players' hands with the measures of the balls of different age categories, men and women.

Objectives
The main objective of this study is to find the coverage index of the dominant hand of handball players, men and women, and to analyze the relationship or proportion of that coverage index among sports categories: infantile, cadet, junior and senior, according to sex.

[1] Ball coverage index, of Porras, Oliver and Sosa, is a new term, coined by the authors, in recognition of those who devised the procedure for calculating this index.

So, we can understand and analyze whether the official size of handball balls by age category, male and female, are proportionally well determined, and depending on the results, propose the official bodies responsible of drafting of the Rules Game of Handball, the size that should have the balls of the women to be equal and achieve proportional ball coverage indices than men of the same age category.

Methods

Participants

The study was conducted with a sample of 1612 Spanish handball players (although in the case of the senior also with some foreign players of both sexes). It comes to 779 women and 833 men, grouped by sex and age category. As regards senior category (over 18 years old) is concerned, participated in the study 98 athletes, 49 women and 49 men. The women belonged to the National Teams of Spain, Brazil and the Netherlands, while the men belonged to Spanish clubs of highest male Division, called "Asobal League"; namely the F.C. Barcelona, BM Granollers and Ciudad Real.

Table 1 *shows in detail the characteristics of the sample.*

Tabla 1. Characteristics of the sample.

		N (1612)	Sample %
Sport	Team Handball	1612	100
Sex	Women	779	48,32
	Men	833	51,67
Age category	Under 14	534	33,12
	Under 16	498	30,89
	Under 18	482	29,90
	Senior (+18)	98	6,07
Sex and age category	Women Under 14	266	16,50
	Men Under 14	268	16.62
	Women Under 16	245	15,19
	Men Under 16	253	15,69
	Women Under 18	219	13,58
	Men Under 18	263	16,31
	Women Senior (+18)	49	3, 03
	Men Senior (+18)	49	3,03

Measure instrument

As we had to measure a very high number of athletes, specifically 1612 hands of Handball players in a very short space of time (using different championships organized in a concentration system) and in full competition, was decided to use a method in which data collection were rapid, valid and effective. Thus, and having studies as reference in which the hand is drawn on paper (Fallahi & Jadidian, 2011; Jürimäe, Hurbo, & Jürimäe, 2009; Visnapuu & Jürimäe, 2007, 2008), we adapt this method and we used the forward by the authors in previous studies (Oliver, 2010, Oliver & Sosa, 2011a, Oliver & Sosa, 2011b).

As data collection instrument we used graph paper notebooks of 100g/m2, A4 size, Guarro's brand, with millimeter grid, both horizontally and vertically. Ballpoints pens, BIC's brand, were also used (fine point: 0.8mm, line width 0.4mm), as well as millimetered rules for the measurement accuracy and to be as accurate as possible. Always was used a table where the graph paper was placed on it, as well as the dominant hand of each athlete, with the palm of the hand on graph paper and completely open.

Procedure

We proceeded to take the following measures:
First measure: from the outside of the distal phalanx of the thumb to the outside of the distal phalanx of the little finger. Second measure: from the outside of the distal phalanx of the thumb to the outside of the distal phalanx of the middle finger. Third measure: from the outside of the distal phalanx of the middle finger to the outside of the distal phalanx of the little finger. These measures were taken with the palm completely open. With these three measures we proceeded to determine the mean of each, and based on these, calculate the coverage index of each athlete's hand, and the mean of each Age category, with the aim of analyzing the results and draw conclusions according to sex and age category.

The procedure followed to discover and calculate the "ball coverage index", explained in summary form, was as follows:
The three measures of the athlete's hand triangulate in the plane, to later transpose them to the situation in space. As shown graphically in **Figure 1**, we place the point O (distal phalanx of the thumb), the point A (distal phalanx of the middle finger) and the point B (distal phalanx of the little finger). We take these points because they are what we are going to define the claw of athlete when adapting the ball.

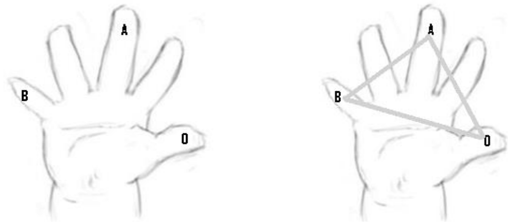

Figure 1. *Points to determine athlete's claw (distal phalanges of the 3 fingers).*

With these three measures (OA, OB and AB), and calculating their coordinates in the Cartesian axis and its perpendicular bisectors we determine an interior point that we call C that corresponds to the circumcenter of the triangle OAB.

As shown in **Figure 2**, the point C, the circumcenter, is the place where they intersect the three bisectors of a triangle and is the center of the circumcircle that will determine the grip area of the ball.

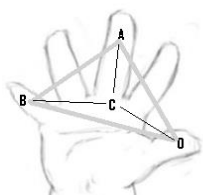

Figure 2. *Circumcenter (C), place that intersect the three bisectors of a triangle. Is the center of the circumcircle that will determine the ball's grip area.*

We take the circumcenter to the distances CA, CB and CO are equal, and so, to proceed to grip the ball, will be at the pole of the ball, and the points O, A and B will determine a not maximum circumference and parallel to the ball Ecuador, as illustrated in **Figures 3 and 4.**

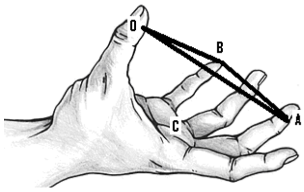

Figure 3. *The circumcenter (C) is located at the pole of the ball, and the points O, A and B determine a not maximum circumference and parallel to the ball Ecuador.*

The distance CA with respect to distance CE (quadrant of the circumference of the ball) is the one that determines the coverage percentage of player's hand over the ball with respect to the official ball of his sex and aged category.

Therefore, in order to determine whether there are differences in the percentage of coverage of the ball for each age category according to sex, the index *I,* is calculated, being:

$$I = \frac{CA}{CE} \bullet 100$$

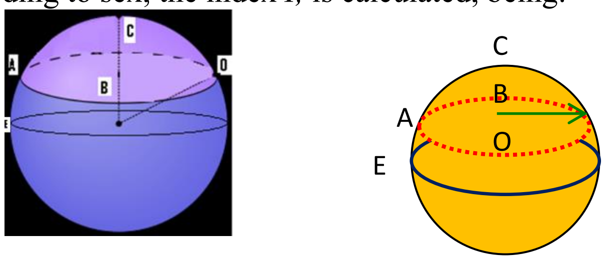

Figure 4. *The circumcenter (C) is located at the pole of the ball, and the points O, A and B determine a not maximum circumference and parallel to the ball Ecuador (dashed line in the illustrations).*

For example, the initial triangle vertices (O, A, B) are the grip points of the ball, and will be situated on the circumference of dotted line, and the circumcenter (C), on top of the ball (**Figure 4).**

The radius of this circumcircle of the triangle will have the same length as the fraction of quadrant covered by the player's hand from (C) to the cutting point with the circumference points.

Finally, the ball coverage index is the ratio of the fraction of quadrant (CA) and total quadrant ball (CE).

So, **the coverage index of the player's hand over the ball** is set as the length of the meridian quadrant of the area covered by the hand with respect to the total.

Results

The mean of the distances, or free space between the fingers, is shown in **Table 2.**

Table 2. Averages of each of the measures of the distances between the toes by sex and Age category

N=1612	Women (N=779)				Men (N=833)			
Age category		Thumb-Litle finger	Thumb-Middle finger	Middle-Little finger		Thumb-Litle finger	Thumb-Middle finger	Middle- Little finger
	N	Mean (cm)			N	Mean (cm)		
Under 14	266	19,84	16,31	10,01	268	20,93	16,95	10,20
Under 16	245	20,06	16,52	10,06	253	21,63	17,86	10,29
Under 18	219	19,69	16,28	9,71	263	21,88	17,93	10,41
Senior (+18)	49	19,57	15,49	9,83	49	21,94	17,56	10,47

Applying the ball coverage index formula (explained above) to the data of **Table 2** gives us the results presented in **Table 3.**

Table 3. Ball coverage index calculated by sex and age category.

Age category	Ball's size used to calculate the C.I.B. (cm)		Ball coverage index (%)	
	Women	Men	Women	Men
Under 14	51 cm	55 cm	78,30	77,05
Under 16	55 cm	55 cm	73,40	79,43
Under 18	55 cm	59 cm	72,16	75,03
Senior (+18)	55 cm	59 cm	72,11	75,60

Discussion

Analyzing the results presented in **Table 3**, we see that women have a lower ball coverage index in all age categories compared with the coverage index of men of the same age category, except in the Under 14 category. Since we want ball coverage indices are proportional between the sexes, we do the calculations, with reference, first, ball coverage indices achieved by men, and secondly, those obtained by women in each age group, to see what should be the size of the ball, in each age category, to be proportionally equalized both sexes.

- If we consider the men's ball size and their coverage index, in **Table 4** are reflected the balls' s sizes with which women should have to play to be proportional with men.

Table 4. Proposal for ball size for women, taking as reference the ball and coverage index of men, in each age category.

Age category	Current size of men´s balls (cm)	Current size of women´s balls (cm)	Women should have to play with these ball size (cm)	Proposal: Sizes of ball for women (cm)
Under 14	54/56 (55)	50/52 (51)	51,83	50/52 (51) Equal
Under 16	54/56 (55)	54/56 (55)	50,85	50/52 (51) Smaller
Under 18	58/60 (59)	54/56 (55)	52,88	52/54 (53) Smaller
Senior + 18	58/60 (59)	54/56 (55)	52,45	52/54 (53) Smaller

- If we consider the women's ball size and their coverage index, in **Table 5** are reflected the balls' s sizes with which men should have to play to be proportional with women.

Table 5. Proposal for ball size for men, taking as reference the ball and coverage index of women, in each age category.

Age category	Current size of men´s balls (cm)	Current size of women´s balls (cm)	Men should have to play with this size (cm)	Proposal: Sizes of ball for men (cm)
Under 14	54/56 (55)	50/52 (51)	54,12	54/56 (55) Equal
Under 16	54/56 (55)	54/56 (55)	59,60	58/60 (59) Bigger
Under 18	58/60 (59)	54/56 (55)	61,36	60/62 (61) Bigger
Senior + 18	58/60 (59)	54/56 (55)	61,87	60/62 (61) Bigger

Conclusions and proposal for changing women' s ball size

Women have a lower ball coverage index than men in all age categories except in Under 14. Thus, given the two proposals presented in Tables 4 and 5, and highlighting that our objective is not increase the men's ball sizes, **we defend the proposal of Table 4**. This is, maintain the sizes of men's balls, and **change the sizes of women's balls**, supported by the results of this study, which are line with the results already obtained by the authors in previous studies (Oliver, 2000, Oliver & Sosa, 2011a, 2011b).

Age category	Current size of women´s ball (cm)	Proposal: Sizes of ball for women (cm)
Under 14	50/52 (51)	50/52 (51) Equal. Current size 1
Under 16	54/56 (55)	50/52 (51) Smaller! Current sixe 1
Under 18	54/56 (55)	52/54 (53) Smaller! New size 1,5
Senior + 18	54/56 (55)	52/54 (53) Smaller! New size 1,5

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THE EHF SUMMER CAMP FOR GIRLS 2013 AT THE AWFIS GDANSK/POLAND FEATURING THE PILOT TEST OF BALL SIZES FOR FEMALE PLAYERS

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Summary
In the framework of the regular EHF summercamp for girls U15 at the site of the AWFIS Gdansk a pilot test concerning ball sizes for female players was carried out. Following an initiative of the MC adidas provided balls of size 1.5 which gave the chance for a multifunctional test including ball speed and accuracy in shooting, the impressions of the players and the opinions of the coaches. The results and further suggestions are discussed.

The Summer Camp
As from 2010 every summer more than 100 female Polish handball players U 15 gather together in the site of the AWFiS Gdansk for 10 days of sport, training and fun. This EHF Summer Camp is organized in cooperation with the Polish Handball Federation and the AWFiS Gdansk. The frame follows the philosophy that was defined in the 2005 EHF Model Course for Summer Camps that took place in Germany.

Activities in this camp include specific training in handball, training in athletics and gymnastics, various kind of games, outdoor activities like sailing and sightseeing as well as shopping, but first all a lot of handball matches played in different forms of friendly tournaments. In this way the summer camp Gdansk still follows the genuine program that was issued in a DVD as well as in written text and still can be found in the files of the EHF web periodical.

From the start the summer camp Gdansk was linked to additional purpose like the selection of some representative teams as well as the installation of a national coaches´ course that was established in the first weekend of the camp. Unfortunately the Gdansk summer camp is still the one and only organized by a national federation in cooperation with the EHF following the philosophy and the program. We do think that other federations should think again on that activity and try to establish an event like that in their home country as well, may it be for girls or for boys or even a joint camp for both.

The pilot test of the ball sizes
The 2013 edition of course was somehow different because it was linked to the EHF Youth Coaches Seminar that took place in the framework of the W17 ECh. For this purpose the girls of the camp had to undergo a selection process in order to establish the demonstration team for the seminar. 22 girls were selected out of more than 100 as the demonstration team and this very group (but without goalkeepers) was the test group for the shooting test.

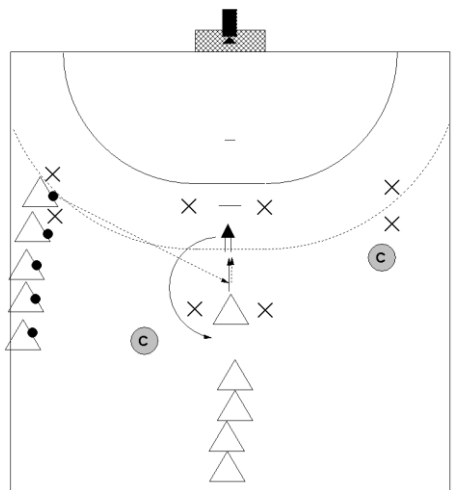
This group performed all the demonstration sessions with balls of size 1.5, the other girls still used balls of size 2 in their drills. EHF contract partner adidas had provided balls of size 1.5 following a last year’s request by the MC who had asked for this size of the ball and at the same time for a tissue with some softer touch in favor of the goalkeepers because a smaller ball does feel harder in the hit always. The test tournament of the groups was played with balls of size 2 in the first half and with balls size 1.5 in the second half of the games. The matches were monitored in order to detect any differences in the play that could be based to the different size of the respective match ball.

A questionnaire was handed out to the players that consisted of 7 questions and another one to the coaches consisting of 8 questions.

The procedure of the shooting test

20 court players were involved in the shooting test, 3 of them lefthanders. All of them had to execute 5 valid shots per turn. Shots after a bad pass or miscatch were repeated as well as shots that were not registered by the radar speedometer Speed Trace X 5200 by EMG Companies Inc. /USA. That gave a total of 100 valid shots per turn.

1st run: ground shot from 9m



Pict.1: *Basic set up* **Photo 1:** *Basic set-up*

In the basic set-up the positions were defined:

The first player had to start on 12.5m, she was to receive the ball on 11m and to shoot from 9m. The pass was done by the player on the 9m line in 7m distance from the base line. After the shot the feeder had to go for the ball and the next pass was done by the second player in the queue.

After the shot the striker had to return to the start line by jogging and start for the next shot. Every player had to execute 5 shots straight. Then she had to go for passing and the first feeder was to queue for shooting.

This is the procedure for the right-handers; the lefthanders received the ball from their right side just in a flip-flop set-up.

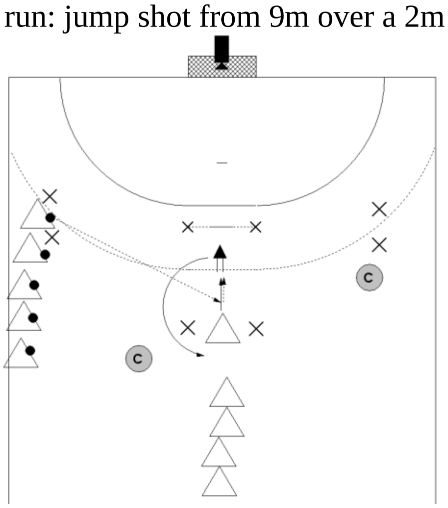
Photo 2: *Speedometer behind the goal*
2nd run: ground shot from 9m including target wall.

Photo 3: *Execution of the 1st run*
Target: throwing arm side high

Photo 4: *Speedometer in front of the target wall – low targets are blocked*

Photo 5: *Execution of the 2nd run*

3rd run: jump shot from 9m over a 2m high band-obstacle positioned at 7m



Pict. 2: *Set-up for the jump-shot*

Photo 6: *The band-obstacle from1.80m to 2.00m*

For the jump shots we had to bring in the two coaches of the group for security reasons. They fixed the obstacle in order to eliminate any danger in case of a hit shot at the obstacle.

The rest of the set-up remained identical to that one of the ground shot.

Photo 7: *Execution of the 3rd run*

4th run: jump shot from 9m over a 2m high band-obstacle positioned at 7m including target wall. Target: throwing arm side high. The speedometer was in the front of the target wall. The rest of the set-up remained unchanged.

All the shots and hits were listed and transferred to an excel-sheet. With this the mean and the variance of all the respective shots were calculated and t-Tests were executed. All the data is documented in the appendix 1- 4.

Results of the shooting test

Ball Size 2	Ground shot	Ground shot + Target wall	Jump shot	Jump shot + Target wall
Speed mean	59,95	54,5	54,08	50,3
Variance	40,41	49,6	36,88	37,77
Hits		17		23

Table 1: *Results with Ball Size 2*

Ball Size 1,5	Ground shot	Ground shot + Target wall	Jump shot	Jump shot + Target wall
Speed mean	65,57	56,96	57,6	53,04
Variance	44,87	39,43	50,22	46,69
Hits		28		26

Table 2: *Results with Ball Size 1.5*

Summary of the results and the calculating

1st There was no significant difference in the jump shot between shots executed with balls of size 1.5 or 2. This applies to the speed of the shots as well as to the accuracy. The remarkable difference is that the variance with ball size 1.5 is bigger.

2nd All the shots are more or less identical in terms of ball speed with the exception of ground shots without target where the resulting speed is significantly higher with the ball size 1.5.

3rd There are extremely few hits in the ground shot with ball size 2, even significantly fewer than in the jump shot with ball size 2.

4th There is no significant difference in the figure of hits with ball size 1.5.

Conclusion of the results

The first one comes as a surprise – obviously the girls were much better trained in terms of the jump shot than for the ground shot and they were more familiar with it by far. This is indicated by the low number of hits in the first place and by the low figures in the variance in the second place.

This leads us to the second important fact – the advantage of the smaller ball is a direct function of the technical level. There is a bigger advantage of the smaller ball in lower levels of technical performance.

And from this we take the third fact – it clearly makes sense to minimize the ball size with the younger players in the first place.

Remark

Of course this pilot test does not allow drawing conclusions on the adult players so we do exclude any speculations on that issue. As for the observation of the tournament matches no real difference could be watched when changing the ball size for the second half of the games. The higher number of fastbreaks in the second period could be seen as a difference but this might as well occur due to fatigue.

Questionnaire for the players

The questionnaire consisted of 7 questions dealing with the subjective feelings and impressions of the players when using the ball size 1.5 In every one of the questions 90% of the players or more stated that they felt more comfortable with the smaller ball. The only exception is the question about the impression of softness when only some 60% felt some difference.

Conclusion

Leaving the technical facets aside now we have to state that from the psychological point of view this is a clear vote for the smaller ball. Feeling more comfortable means that they will be encouraged to learn more difficult technical solutions in shorter time. The motivation aspect will give an additional kick and more comfort will lead to more self confidence and further on it will foster the level of self value which has to be seen as a crucial factor in learning as well as in performing.

Questionnaire for the coaches

The questionnaire for the coaches dealt with impressions and opinions concerning differences in offense, defense and the goalkeeper play. These questions were much more in detail than those ones of the player´s questionnaire and gave room to personal opinions and suggestions.
Summary of the impressions and opinions of the coaches: In general the trend of the impressions was that the smaller ball would improve the offense play without harming the defense play on the other hand. They felt that fastbreak play was improved because of more courage to execute long range passes was noticed. Also the coaches did not expect any disadvantage for the play of the goalkeepers.

Conclusion
The coaches did appreciate the advantages of the smaller ball and would like to play with it on regular terms. One very important remark was that the gap from playing with size 1 to jump to size 2 gives some problems to many players and the coaches do hope that these problems could be eliminated by the ball size 1.5.

Final summary and remarks
This pilot test included a technical test set up as well as observation and psychological aspects of the issue covered by questionnaires.

The shooting test proved that the smaller ball does give a clear advantage for learning technical solutions faster and easier.

The questionnaire for the players can be summed up in that way that most of the players do feel more comfortable with the smaller ball which is a very important psychological aspect. More comfort will lead to more self confidence more self confidence will motivate them to try and practice more difficult technical solutions.

The coaches do think that the offense play will be improved without negative effects on the defense or the goalkeeper play. As we all know better offense play within a short period of time forces better defense play as well which will mean that we can assume an overall improvement of the game.

Please allow us some final remarks:
This pilot test should of course be seen as a first step of a series of test in laboratory, match-alike and match situations. National federations shall be invited to carry out test programs in some tournaments or even national competitions. Talking to the coaches and officials of the German team they were very fond of the possible chance to test smaller balls in the future because as you all might know, glue is not allowed in German competitions of the youngsters. So we are looking forward for many other steps and approaches to that issue in the near future and we do hope that our step was only the first small one.

Thank you very much for your attention and your patience.

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FUNCTIONAL MOVEMENT SCREEN OF YOUTH FEMALE SLOVENIAN HANDBALL PLAYERS

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Summary
The objective of the research was to evaluate the fundamental movement patterns of youth female handball players, while using the Functional movement screen (Cook, 2010). In four tests we confirmed statistically significant differences in asymmetries between the left and the right side of the body. These results are alarming, regardless of age of the subjects. Previous investigations have demonstrated that defects in fundamental movements can put an athlete at greater risk of injuries.

Keywords
Team handball, Female youth players, Functional movement screen

Introduction
The proper execution of fundamental movement patterns is very important for motor development of young handball players. These movements represent the foundations for more complex movements and skills.

The agile character of the team handball game is associated with a number of unexpected situations, external disturbances of movement and extreme positions of body segments which can be a cause for a lot of injuries (Olsen, 2005). Most movement structures, also known as acyclic activities, are carried out unilaterally, which is a significant feature of handball. Unilateral movements are manifested in different forms of throws and jumps with the dominant extremity as well as core rotations, predominantly to one side. Due to the aforementioned dominance of unilateral movements and the constant burdening of mostly one side of the body, adaptation and disparities both in the muscle as well as skeletal system of the players can be expected. Other frequent issues of young people during puberty, such as a short hamstring and core flexors, poor posture due to a sedentary lifestyle, increased weight, etc, can be added to the issues mentioned above. All of the above can lead to decreased motor efficiency (Šarabon, Fajon, Zupanc and Drakslar, 2005).

Movement efficiency is, by definition, the product of learned movements and levels of development of motor abilities. It is largely dependent on maturity of nervous system, bones, muscles and the hormonal balance in the body, and most of all depends on the physical activity of children and youths, as well as grown athletes (Škof, 2007). In general movement efficiency is limited by six motor (strengths, speed, coordination of movements, flexibility, balance and precision) and aerobic abilities. For the execution of movement tasks, coordination of movements, strength and balance are most important. For the efficient functioning of the human body it is very important that the movements (muscles) are coordinated into appropriate movement patterns. They have to be a logical part of a kinetic chain, where the energy, as well as force, can be optimally transferred from proximal to distal parts of the body. Poor strength of certain muscle groups in the kinetic chain as well as inadequate amplitude of joint movements, can lead to compensatory or dysfunctional movement patterns (Becham, & Harper, 2010), which can deteriorate the athletes performance. Compensatory movements in extreme circumstances, such as handball trainings and matches, can exacerbate the condition and cause bigger issues due to poor execution of movements (Boyle, 2004). This can cause injury or termination of an athlete's career in the long term. The consequence of compensatory movement can manifest in asymmetry in strength and motility between the left and the right side of the body (Okada, Huxel, & Nesser, 2011). Issues in the functioning of the neuromuscular system, which manifest as disparities in lengths of muscle, anatomical changes such as deviations in the curvature of the spine, inconsistencies in the motor development of adolescents, etc., can occur (Cook, 2010).

In recent years the Functional movement screen (FMS) (Cook, 2010) has been deemed an efficient and reliable system to evaluate basic movement patterns. The test is comprised of seven fundamental movement patterns that require a balance of mobility and stability. These patterns are designed to provide observable performance of basic loco motor, manipulative and stabilizing movements. The tests place the individual in extreme positions where weaknesses and imbalances become noticeable if appropriate stability and mobility is not utilized. It has been observed that many individuals who perform at very high levels during activities are unable to perform these simple movements. These individuals should be considered to be utilizing compensatory movement patterns during their activities, sacrificing efficient movements for inefficient ones in order to perform at high levels. If these compensations continue, then poor movement patterns will be reinforced leading to poor biomechanics (Cook, Burton in Hoogenboom, 2006).

The objective of the research was to evaluate the fundamental movement patterns of youth female handball players and to analyse possible asymmetries and dysfunctional movement patterns.

Methods

Participants

The participants consisted of 49 youth female handball players (age: 14,2 ± 0,9 years, height: 169,6 ± 6,9 cm, body weight: 60,2 ± 7,6 kg) and 15 non-athletes females who represented a control group (age: 14,5 ± 1,1 years, height: 164,6 ± 5,7 cm, body weight: 57,2 ± 4,6 kg). All subjects were in good health at the time of testing were given and with parents' approval to take part in the experiment.

Instruments

To carry out the measurements we used the Functional Movement Screen (Cook, 2010) measuring system. It consists of seven tests, two of which are bilateral (Deep squat (DS), Trunk stability push up (TSPU)) and five are lateral (Hurdle step (HS), In-line Lunge (IL), Active Straight-leg raise (ASLR), Shoulder mobility (SM) and Rotary stability (RS)). Each of them is marked with four possible grades. The mark "3" means a perfectly executed test, mark "2" describes the execution with smaller movement deficits or compensatory movements, and mark "1" means the participant was not able to perform the prescribed motor tasks. In case of pain during motor tasks, the candidate receives the mark "0", regardless of the quality of the execution. For the execution of each test the participant has three tries, and the highest recorded mark is taken into account. When the participant scores a "3" on the first try, further repetition is not necessary. For tests carried out on both sides of the body, the lower of the individual marks is selected as total mark. The highest total mark for the FMS test equals to 21 (Cook, 2010).

Procedures

The measurements ware carried out on two separate occasions. The measurements in the experimental group were carried out at the end of August 2013 at a camp of the Handball Federation of Slovenia in Piran, and the measurements of the control group in mid-May 2013 in the gym of School Centre Velenje.

The participants are not allowed to be physically active prior to testing, therefore the tests were carried out without warm up or stretching. The participants were made familiar with the test prior to execution, yet received no detailed instructions in accordance to Cook (2010).

The results of individual tests were noted and input into pre-prepared forms, and managed with Microsoft Excel and statistical analysis programme SPSS. The statistical analysis included descriptive statistics procedures. To determine the statistical differences in estimates between the different groups, we used one-way analysis of variance. Statistically significant differences between the left and right sides of the body of participants were determined by a T-test of pairs. Statistical significance was tested with a 5% alpha error.

Results

Table 1 demonstrates the comparison of average marks for selected tests of the experimental and control group. The total average mark for all seven tests of the experimental group was 15.6 ± 2.1, and 16.00 ± 2.1 for the control group. The distinction was not statistically relevant.

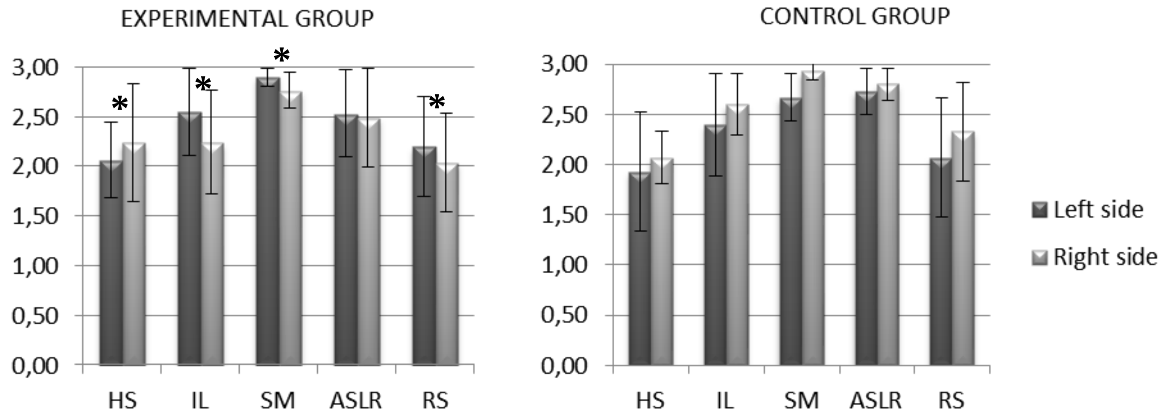
Highest average marks in both groups were noticed in the Shoulder mobility (SM) test, while the participants performed on average the worse in Hurdle step (HS) and Trunk stability push up's (TSPU). Statistically significant differences between the experimental and control group were evident in the following tests: HSR (p= 0.000), SML (p=0.004), SMD (p=0.003), ASLR (p=0.008), ASLRL (p=0.013), ASLRR (p=0.00) in TSPU (p=0.001) (Table 1).

We were also interested in possible statistically significant differences in average marks for tests, measuring the left and right side of the body within both analysed groups. T-tests of pairs demonstrated the control group of our sample did not present statistically significant differences in average marks for the left and right side of the body in any of the five tests (Figure 1). We found very different results in the experimental group, since statistically significant differences manifested in four out of five tests, namely the HS (p=0.040), IL (p=0.000), SM (p = 0.005) and RS (p = 0.020) (Figure 1).

Table 1: *Comparison of average marks in the tests of the experimental and control group*

	EG (n=49)	CG (n=15)	Sig. (* p < 0,05)
DS	2,2±0,6	2,4 ± 0,5	0.829
HS	1,9 ± 0,4	1,9 ± 0,5	0.159
HSL	2,1 ± 0,4	1,9 ± 0,6	0.089
HSR	***2,2± 0,6***	***2,1 ± 0,3***	***0.000****
IL	2,2 ± 0,5	2,3 ± 0,5	0.362
ILL	2,5 ±0,4	2,4 ± 0,5	0.452
ILR	2,3 ±0,5	2,6 ± 0,3	0.524
SM	2,7 ±0,3	2,7 ± 0,3	0.918
SML	***2,9 ±0,1***	***2,7 ± 0,3***	***0.004****
SMR	***2,8 ±0,2***	***2,9 ± 0,1***	***0.003****
ASLR	***2,5 ±0,4***	***2,7 ± 0,2***	***0.008****
ASLRL	***2,5 ±0,4***	***2,7 ± 0,2***	***0.013****
ASLRR	***2,5 ±0,5***	***2,8 ± 0,2***	***0.000****
TSPU	***1,9 ±0,7***	***2 ± 0,3***	***0.001****
RS	2±0,4	2 ± 0,5	0.530
RSL	2,2 ±0,5	2,1 ± 0,6	0.872
RSR	2,1 ±0,5	2,3 ± 0,5	0.126
TOTAL GRADE	**15,6 ±2,1**	**16± 2,1**	**0.675**

Key: EG – *Experimental group****, CG –*** *Control group****, DS*** *- Deep squat,* ***HS*** *- Hurdle step,* ***HSL****- Hurdle step left,* ***HSR*** *- Hurdle step right ,* ***IL*** *- In-line Lunge,* ***ILL*** *- In-line Lunge left,* ***ILR*** *- In-line Lunge right,* ***SM*** *- Shoulder mobility,* ***SML*** *- Shoulder mobility left,* ***SMR*** *- Shoulder mobility right,* ***ASLR*** *- Active Straight-leg raise,* ***ASLRL*** *- Active Straight-leg raise left,* ***ASLRR*** *- Active Straight-leg raise right,* ***TSPU*** *- Trunk stability push up,* ***RS****- Rotary stability,* ***RSL****- Rotary stability left,* ***RSR****- Rotary stability right.*



Key: * - p<0,05***, HS*** *- Hurdle step,* ***IL*** *- In-line Lunge,* ***SM*** *- Shoulder mobility,* ***ASLR*** *- Active Straight-leg raise,* ***RS****- Rotary stability*

Figure 1: *Comparison of average marks for the left and right side of the body in lateral tests of the experimental and control group*

Discussion

The average total mark of the experimental group (EG) was 15.6 ± 2.3, and 16± 2.1 for the control group (CG). There were no statistically significant differences between them. Small differences in the average total mark between the EG and the CG were surprising, since we expected that selected handball players, who on average train 4 times per week would demonstrate better performance than their peers, inactive in sports. This analysed variable demonstrates poor general sports education as well as non-systematic training process of young handball players in terms of diagnostics and training movement patterns. The results of the average total score of the players included in our sample are similar to the research on samples of American football players, soldiers, firemen, and young regularly physically active athletes reported by Kiesel, Plisky, and Voight (2007); O'Connor, Deuster, Davis, Pappas, and Knapik (2011); Goss, Christopher, Faulk, and Moore, J. (2009) and Schneiders, Davidsson, Hörman, and Sullivan (2011). The latter study is one of the regularly published researches conducted on a sample of relatively young athletes. The average age of the sample in Schneiders, et al (2011) was 22, while other studies were carried out on adult population.

The comparison of average marks achieved in individual tests between EG and CG demonstrated statistically significant differences in four tests, namely the Hurdle step right (HSR), Shoulder mobility left (SML), Shoulder mobility right (SMR), Active Straight-leg raise (ASLR), Active Straight-leg raise left (ASLRL), Active Straight-leg raise right (ASLRR), Trunk stability push up (TSPU). Better results of the EG in the HSR test can be explained by the use of the jump shot technique, which is a very frequent element of handball, so the players experience conditions similar to the HSR. Hip flexion and abduction on the side of the dominant hand (usually the right) occurs, as well as unilateral take of with the dominant leg. Somewhat surprising are the results in the ASRL tests, which mainly focuses on the mobility of hamstrings, since the results in the EG are worse than in the CG. In the TPSU test the handball players performed worse than their peers in the CG, despite having the advantages of the handball games and the training process, which should increase the strength of the upper body and torso stabilizer activation of the athletes. In general, the rise into a push-up was the worst rated test among all the girls, which is consistent with the findings of several other studies (Chorba, Chorba, Bouillon, Overmyer, and Landis (2010); Schneiders et al, (2011)). The lower average mark of the EG in SMR is somewhat expected. In handball unilateral movements with the dominant hand are most comment. The consequences of a high number of repetitions in trainings and during games can manifest in a larger strength of the dominant arm and decreased mobility and flexibility in the shoulder joint.

During the study we wanted to know if young selected handball players experience any asymmetry in the musculo-skeletal system. To this end we examined the differences between the marks of the left and right side of the body within EG and CG in five testes, conducted on both sides. While the CG demonstrated no statistically significant differences, the EG showed statistically significant differences in four tests (HS, IL, SM and RS). The acquired results from our sample demonstrate that acyclical unilateral movements in handball can affect the changes and adaptations of the musculo-skeletal systems of the players. This fact is worrisome, since they demonstrate asymmetry between left and right in very young players. Of course, we cannot predict if the asymmetries will be eliminated or exacerbated by further development of the body and the training process.

We suggest including professionally prepared preventive programmes early enough in the training process which includes contrast and corrective exercises for the most sensitive and exposed parts of the body. The results of some studies (Kiesel, 2009; Goss, 2009; Bodden, 2013; Klusemann, 2012) confirmed that an appropriate programme of the functional training can improve the total FMS score and mostly eradicate asymmetries and decrease the risk of injury.

Conclusions

These results reveal some unpleasant truths that are reflected in changes of the musculoskeletal system of young handball players. We suggest including professionally prepared preventive programmes early enough in the training process which includes contrast and corrective exercises for the most sensitive and exposed parts of the body.

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HANDBALL 4 HEALTH – EFFECTS OF A SHORT-TERM HANDBALL BASED EXERCISE PROGRAMME ON HEALTH AND PERFORMANCE MARKERS IN UNTRAINED ADULTS

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Summary
This study analyses the effects of a short-term handball based exercise programme on health and performance markers in untrained male adults. Sixteen participants (33-55 yrs) performed 2-3 sixty min training sessions/week consisting of playing handball matches, interspersed by a ten min half-break, during twelve weeks. Preliminary data shows positive performance and health-related changes, which may contribute to reducing the risk of developing lifestyle diseases.

Keywords
Team handball; health and performance markers; untrained male adults.

Introduction
In modern society, the adoption of sedentary lifestyles results in low physical fitness levels, one of the most important risk factors for chronic-degenerative diseases, especially those related to the cardiovascular system. Epidemiologists and public health promoters have focused on the detection and prevention of modified risk factors that are associated with these diseases, particularly, low cardiorespiratory fitness, throughout exercise interventions since exercise is associated with a decreased risk of cardiovascular and metabolic diseases (Halbert et al., 1997; Jeon et al., 2007). Nonetheless, few studies have investigated the health effects of regular participation in a variety of team sports (Saltin et al., 1979; Krustrup et al., 2009, 2010; B. Krustrup et al., 2007). Handball is a high-demanding intermittent exercise that primarily uses the aerobic metabolism, interspersed by high-intensity actions that greatly tax the anaerobic metabolism due to numerous high-intensity displacements and actions (Póvoas et al., 2012). Thus, the purpose of this study was to describe the effects of a short-term handball based exercise programme on health and performance markers in untrained male adults.

Methods
Sixteen participants (42.3±7.11 yrs; 179.4±7.25 cm; 98.3±9.59 kg and 22.0±5.17% fat mass) performed two to three sixty min training sessions consisting of playing handball matches, interspersed by a ten min half-break, per week, during twelve weeks. Health and performance evaluations were performed at baseline and at the end of the intervention. All subjects were previously informed about the aims of the study, the risks associated with the experiment and familiarized with all testing protocols and procedures before delivered written consent to participate. The experimental protocol was approved by the local ethics committee and followed the Declaration of Helsinki of the World Medical Association for research with humans.

Height was measured to the nearest millimeter in bare feet with the participants standing upright against a stadiometer (Holtain Ltd., Crymmych, Pembrokeshire, UK). Weight and percentage of fat mass (%FM) were measured in a portable electronic weight scale (Tanita Inner Scan digital BC 532) with participants using shorts. Weight was measured to the nearest 0.10 kg. Waist and neck circumferences were measured accordingly to Lohman et al. (1991) and the average of the two measures was used for analysis.

Blood pressure was measured using the Dinamap adult vital signs monitors, model BP 8800 (Critikon, Inc., Tampa, Florida).

The participants performed an incremental treadmill (Quasar-Med, Nussdorf, Germany) test (Noakes, 1988) until voluntary exhaustion to determine peak oxygen consumption (VO2peak). Expired respiratory gas fractions were measured using an open circuit breath-by-breath automated gas-analysis system (Cortex, Metalyzer, 3B, Leipzig, Germany).

Upper muscle strength performance was evaluated using the push-ups test from Fitnessgram Test Battery 8.0 (Welk & Meredith, 2008) and specific endurance was assessed by the Yo-Yo intermittent endurance test–level 2 (YYIE2) (Bangsbo, 1994).

A single-legged flamingo balance test was used to evaluate postural balance control (Deforche et al., 2003). Subjects were instructed to stand on the dominant leg with their eyes open on a 3 cm wide and 5 cm high bar, while the free leg was flexed at the knee joint and held at the ankle joint close to the buttocks. The number of falls was counted during one minute of stance as a measure of postural balance. The participants had one trial and a 1-min period of familiarization was performed before all the tests.

Statistics

Changes in health and performance parameters between baseline and the end of the intervention were determined by Student's paired t-test. Statistical Package for the Social Sciences (SPSS Inc, version 17.0) was used for all analyses. Statistical significance was set at $P \leq 0.05$.

Results

Preliminary results (Table 1) show that VO2peak (40.2±7.02 vs. 44.8±7.03 mmol.kg^{-1}.min^{-1}; $P < 0.01$), YYIE2 (351±148.9 vs. 575±466.6 m; $P = 0.05$) and upper muscle strength performance (22±13.6 vs. 32±14.0; $P < 0.01$) increased from baseline ($P \leq 0.05$). Also, postural balance was improved as shown by the decrease in the number of falls in the flamingo balance test (16±9.2 vs. 11±4.3; $P = 0.01$).

Systolic (134±11.8 vs. 128±12.5 mm Hg; $P = 0.03$) and diastolic blood pressure (78±10.3 vs. 73±6.5 mm Hg; $P = 0.01$) values at the end of the intervention were lower than baseline values. Additionally, there was a decrease in waist (100.5±9.87 vs. 95.9±7.18 cm; $P = 0.02$) and neck (40.5±1.65 vs. 39.9±1.25 cm; $P = 0.05$) circumferences and %FM (22.0±5.17 vs. 19.7±4.42 %; $P < 0.01$).

Table 1. *Health and performance results (mean ± SD) at baseline and after 12 weeks of a handball based exercise intervention.*

Marker	Baseline	After 12 weeks	*P*
VO_2peak (mmol.kg^{-1}.min^{-1})	40.2±7.02	44.8±7.03	<0.01
Yo-Yo Intermittent Endurance test – level 2 (m)	351±148.9	575±466.6	0.05
Upper muscle strength (N)	22±13.6	32±14.0	<0.01
Postural balance (N)	16±9.2	11±4.3	0.01
Systolic blood pressure (mm Hg)	134±11.8	128±12.5	0.03
Diastolic blood pressure (mm Hg)	78±10.3	73±6.5	0.01
Waist circumference (cm)	100.5±9.87	95.9±7.18	0.02
Neck circumference (cm)	40.5±1.65	39.9±1.25	0.05
%Fat Mass	22.0±5.17	19.7±4.42	<0.01

Conclusions

Preliminary data from the present study suggest that short-term recreational handball practice induces positive performance and health-related changes in untrained male adults, which may contribute to reducing the risk of developing lifestyle diseases.

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FINGERS INJURY PREVENTION IN HANDBALL

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Summary
This review discusses common types of fingers injuries in handball and presents some of the suggestions for fingers injury prevention. As previous researches showed, overall prevalence of acute injuries in handball is around 2/1000h. Match prevalence are ten times higher than training incidences. But with all the focus on knee, ankle, hip, back and shoulder problems associated with handball, finger injuries often receive little or no attention at all.

Keywords
Handball, finger injuries, injury prevention

Introduction
Because of its dynamics, injuries are unfortunately an integral part of the handball game. One of the injuries to which is not given enough attention in handball literature are finger injuries. Finger injuries are common in many ball sports with the most common injury being a sprain to one of the ligaments located within the finger.

Sprained fingers occur when the ball contacts the end of the finger and causes significant swelling of a single joint. A traumatic injury to fingers involves mostly a battle on an outstretched finger, which coats the ligaments and joint capsule. For example, when player or goalkeeper tries to catch (or save) a ball and the ball hits an outstretched finger. But the sprain may result from an impact with an opponent player or a teammate, and then for both handball players and goalkeepers sprain can be caused by a fall or any sudden stretching of a finger.

Also sprain can happen to handball goalkeepers while accidentally hitting the goal post. Or even while performing some of the variations of middle save reactions – when the save reaction requires lifting up the leg and covering the same area also with the hand, then sometimes in the speed of movement it can happen that the goalie hits her/his own finger with her/his foot.

Methods

- **Structured literature & database research**

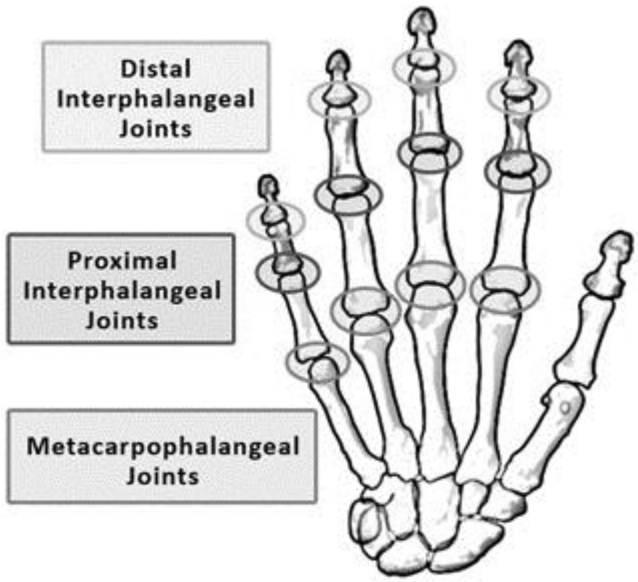
The National Center for Biotechnology Information (NCBI), Physical Medicine and Rehabilitation Clinics of North America (Phys Med Rehabil Clin), STOP (Sports Trauma and Overuse Prevention) , Des Moines Orthopaedic Surgeons (DMOS), American Orthopaedic Society for Sports Medicine (AOSSM), Hughston clinic, FIBA and Google were browsed for corresponding articles and materials.

- **Surveys on fingers injuries and fingers injury prevention in handball, basketball and volleyball**

Results

Hand Structure

Each finger has three small bones (phalanges) separated by two interphalangeal joints. The thumb is unique and has one interphalangeal joint and only two small phalange bones.



There are 14 bones in the fingers**:** 2 in the thumb and 3 in each of the other four fingers. These bones are called *"phalanges"*. There are 5 bones in the palm or "*metacarpus"*. These bones are called "*metacarpals"*. All these bones are connected at their joints by bands of collagenous material called *ligaments.*

Each joint is vulnerable to sprains (partial tearing and disruption of ligaments), strains (over-stretching of the ligaments), dislocations and complete ligament tears during the practice or a match.

Examples of finger injuries in handball include

- fractures
- dislocations
- ligament injuries and
- tendon injuries

Fractures (broken finger bone)

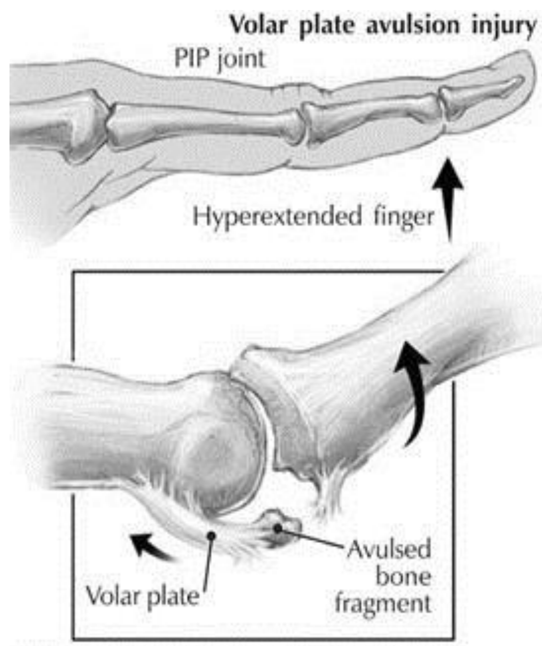
Fractures of the phalanges (fingers) and metacarpals (long bones in the hand) are less common than joint dislocations but occur also as a result of being hit on the end of the finger in handball.

Dislocations
The little finger and the thumb are most commonly affected. Dislocation occurs when the bone comes out of its 'socket' causing damage to the ligaments and capsule around the joint. Dislocations of the joints in the fingers can be combined with fractures. Some dislocations are very difficult to reduce (put back into place) as the bones can push through tendons in the fingers. Also some dislocations will not reduce because of an associated fracture causing instability in the joint - a good example of this is a *Bennett's fracture* (fracture and dislocation) at the base of the thumb.

Ligament injuries
Ligaments are the tough tissues holding two bones together at a joint. A ligament may be torn by a forceful stretch or blow, leaving the joint unstable and prone to further injury.

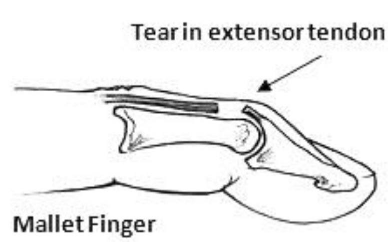
A sprain is an injury to a ligament. Each of the joints located in the finger have collateral ligaments that run along each side of the joints. It is these collateral ligaments that are commonly sprained in handball and many other sports.

The Volar Plate is a hyperextension injury which is essentially a ligamentous injury although it may involve a portion of bone avulsed off by a ligament. It usually involves a piece of bone avulsed off the base of the middle phalanx by the volar plate which is usually not significantly displaced and usually will heal without problem.



Volar Plate injuries are often referred to as a *"jammed finger". The Volar Plate* can be defined as a very thick ligament that prevents hyperextension from occurring. If there is enough force during hyperextension, the disruption may cause a rupture of the *Volar Plate* at its insertion on the middle phalanx of a finger. This would result in a small piece of bone from the middle phalanx being avulsed, (pulled off), by the ligament as it is hyper extending. This injury can often involve a collateral ligament tear. Collateral ligaments provide stability from excessive side-to-side motion at the finger joints.

Tendon injuries
Tendons are the fibrous bands that attach muscles to bones and allow the flexible, precise movements of the joints. Tendons lie just under the skin in the fingers and are covered by a protective sheath. Both the tendon and its sheath can be damaged by a laceration (cut) or a crush injury.



Tendon injuries include *"Mallet finger"* and *"Jersey finger"* where tendons are pulled off bone. *Mallet finger* is a deformity of the finger that occurs when the tendon that attaches to the end of the finger just below the nail is detached from the bone. This may happen when the end of the finger is bent forward when hit on the end, by a ball for example. *Mallet finger* always requires special splinting and occasionally surgery. Symptoms include pain and swelling in the end of the finger accompanied by a deformity of the finger where the end of the finger is permanently bent forward. This is very common finger injury in handball.

Prevention of finger injuries

Preventing sports injuries to the hands and fingers is really difficult. In handball or any ball sport where an object is being thrown at the hand with a rapid rate, players and goalkeepers are likely to get fractures along the fingers, tears of ligaments, and tears of tendons.

Avoid wearing rings

After recalling the tragic accident that occurred in July 2008 to Croatian national team player Ivan Cupic, we must all be aware that it is entirely forbidden for players and goalkeepers to wear rings or other jewelry during a handball practice or a match. Namely, Cupic missed the Games of XXIX Olympiad in Beijing, after losing his left ring finger in bizarre accident. During a training season, Cupic fell and caught his wedding ring on a wire fence. The force of the fall severed his finger at the first joint. Though the amputated portion of the digit could not be reattached, his career has since been unaffected by having only nine fingers.

Handball goalkeepers and players need to know that there are also few things which they can make in their everyday training routine to reduce risk of finger injuries. It is obvious that increased strength of the fingers, hands, wrists, and forearms should be helpful in avoidance of an injury. Within limits, improved flexibility of the fingers, hands, and wrists should also be injury-preventing.

However finger injuries in handball can occur even in players with very strong and flexible hands. If a very fast ball is coming towards a player or a goalkeeper and strikes the end of his/her finger, for example, all the strengthening routines in the world may not prevent that finger from getting a serious sprain, or even a fracture. Nonetheless, a series of strengthening exercises are recommendable to lower the risk of jammed fingers which might occur as a result of lower-force impacts.

Also these exercises are the same as the ones used for rehabilitation of a jammed finger after symptoms have subsided.

Here are some of the suggested exercises for fingers injury prevention:

1. Fingertip push-ups

The fingertip push-up is a classic exercise that can take hand strength and fingers injury prevention to upper level. If player doesn’t have the ability to do fingertip push-ups yet, s/he can practice the isometric plank position on their fingertips.

If not yet able to perform even this plank position, one can try with modified plank on its knees.

Start with a few seconds at a time – eventually s/he should be able to build to a ten-second fingertip plank. Once they have achieved that, they will be ready to start practicing fingertip push-ups. So every time while you are performing normal push-ups during the practice, you can always dedicate at least few repetitions to make fingertip push-ups.

2. The ball squeeze
Place a tennis ball or equivalent in the palm of the hand and squeeze forcefully for a few seconds. Slowly relax the hand. Rest for a few seconds. Repeat.

3. Finger extensions
Place a hand, palm forward, on a wall or other flat surface. Press the palm toward the flat surface as fully as pain permits and hold for five seconds. Return to starting position and rest for five seconds. Repeat this sequence ten times few times a day. The more often the sequence can be repeated in a day, the better.

Conclusions

This review indicates that modification of simple and already used exercises in training process can contribute to fingers injury prevention in handball. As the most simple example is listed fingertip push up exercise. Since the push ups are anyway widely used in handball training both by players and handball goalkeepers.

Fingertip push-ups should be integrated permanently into the training process, starting at the very young age. And in that case combined through the games. In a long term this will strengthen fingers and help in fingers injury prevention.

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COMPARISON OF EFFECTS OF 6 WEEKS OF PLYOMETRICS TRAINING WITH SQUAT TRAINING UPON DIFFERENT MOTOR ABILITIES IN ADOLESCENT HANDBALL PLAYERS

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Summary
The aim of this study was to compare the effects of six weeks plyometrics training with squat training upon different physical performances in adolescent male and female handball players. Half of the group (n=13) conducted the plyometrics while the other half conducted a squat training program twice a week for 6 weeks besides their normal handball practice. Both groups significantly increased their performance after 6 weeks in 30m sprint, agility, 1-RM Squat and YoYo IR1 tests, while no significant changes were found in the CMJ test and a significant decrease in throwing speed. The results suggest that both, a short in-season 6-week plyometrics or squat training regimen can improve physical performances of the lower body, while they will not enhance performance for the upper body.

Keywords
CMJ, Throwing, agility, YoYo IR 1, sprint

Introduction

Team handball is a very popular sport in Europe which includes a lot of different motor abilities, such like endurance, sprint, agility, jumping and throwing. There are a lot of ways to train the different motor abilities, but resistance training with free weights has shown to be positively for jumping (Tsimahidis et al., 2010) and throwing (Hoff et al., 1995). However, several weight training programs had ambiguous results upon sprint, repeated sprint, agility and endurance abilities (Yamamoto et al., 2008). Theoretically the meaning with weight training is to increase the strength of the muscles and thereby changing the force-velocity relationship (Kaneko et al, 1983). By increasing the strength of the muscles it is plausible to increase the performance in sprint, jumping and throwing due to increase maximal force, which would make it easier to throw, jump or sprint with the same absolute weight after training. However, in weight training the execution velocity of the movements is much lower than in regular throwing, jumping and sprint movements. Furthermore, Kristiansen et al. (2006) found training resistance with lower velocity did not have a positive transfer to higher velocities. Training effect of motor abilities often relate to specific execution in performance context. However weight training may have a positive transfer to other motor abilities, and power training with weights has shown to be effective for sprinting and jumping in soccer (Marques et al., 2013a).

Plyometrics training is also often used in handball, which is based upon increasing the rate of force development and stretch shortening cycles during the different movements. Plyometrics training is much more explosive than weight training and would be easier to transfer into the different actions in handball like jumping, sprinting, agility and throwing. However, in most studies on plyometrics training only one (depth jumps) or two (CMJ) plyometrics exercises are used in training with very high intensity, which can influence the injury rate and motivation of the involved subjects, while an integrated short plyometrics training with several small jump exercises could have the same or better effect together with an increased motivation for the subjects, due to the increased variation. Marques et al. (2013b) showed that the use of a short plyometrics training program (consisting of 4 exercises every time) integrated in the regular training had positive results upon sprinting times (+3.2%) and jumping (+7.7%), and kicking velocity (6.6%) in adolescent soccer players.

However, to our best knowledge, no study has investigated the effects of power training with weights (2-legged squats) compared with plyometrics training on jumping, sprinting, agility, endurance and throwing performances in adolescent handball players. Therefore the aim was to investigate these effects over a period of 6 weeks in adolescent handball players. It was hypothesized that both groups would enhance the sprint, jump and agility performance as was found in the studies of Marques et al. (2013a; b) that used the same training programs. In addition it was expected that the throwing performance and endurance would not increase due to the fact that it is not trained extra upon. Furthermore, it was expected that the plyometrics training group would increase more than the 2-legged squat training since plyometrics training is much more explosive in nature, and simulates the movements that are tested.

Methods

26 competitive male and female adolescent handball players (age 13.8 ± 0.5 yr, body mass 57.5 ± 11.5 kg, body height 1.70 ± 0.10 m) participated in the study. The participants were from three different teams playing at national level in their age class. The subjects were fully informed about the protocol before the start of the study. Informed consent was obtained prior to testing from all subjects and parents, in accordance with the recommendations of local ethical committee and current ethical standards in sports and exercise research. The experiment was conducted near the end of the season from February to April.

After a standardized general warm-up of 10 minutes each participant was tested randomly for five tests: 1) for explosive strength of lower limbs by a counter movement jump (CMJ). The participant started from a standing position with their hands on their waist and a A linear encoder (ET-Enc-02, Ergotest Technology AS, Langesund, Norway) around their waist. Then, they flexed their knees to 90°, followed by a jump as high as possible while holding the hands on their waist. The distance from standing position to the highest position measured with the linear encoder was measures as jumping height. Three attempts were made with 1 minutes of rest in between. 2) Sprint performance was tested by three maximum effort sprints of 20 meters using Brower equipment (Wireless Sprint System, USA). Subjects performed trial sprints separated by 3 minutes of rest. Only the best attempt was considered. 3) Agility was tested by an agility test proposed by Mohamed et al. (2009). The agility test showed maximal movement in a specific pattern related to handball movement in defense, measuring the time in seconds. 4) Throwing performance was evaluated by throwing a standard handball ball as hard as possible straight forwards on a target 7m away. The maximal ball velocity was determined using a Doppler radar gun (Sports Radar 3300, Sports Electronics Inc.), with ± 0.028 $m \cdot s^{-1}$ accuracy within a field of 10 degrees from the gun. The radar gun was located 1 m behind the subject at ball height during the throw. In every test three attempts were made and the best attempt was recorded. 5) Lower limb strength was tested in two-legged squats with a weight of 20, 30 and 40 kg. The mean propulsion velocity at each weight was calculated with a linear encoder and including software (T-force, Murcia, Spain) to establish, by linear regression, the training weight of approximately 1 m/s.

Endurance was tested the second day in an own session by conducting the The Yo-Yo IR1 according to the procedures suggested by Bangsbo et al. (1991).

After the pretest the subjects (13 in each group) were equally divided based upon strength performance into a plyometrics training (4 different type of jumps 156-195 jumps per session; table 1) or a squat training group (3*6 of 45% of 1-RM; table 2) who conducted 2 training sessions per week for a period of 6 weeks integrated in the start of their regular training sessions.

Table 1. *Training program with the total repetitions per time for plyometrics training group*

	Training session					
Exercise	**1**	**2**	**3**	**4**	**5**	**6**
2 legged jumps (without bending knees)	3 x 20	3 x 20	3 x 20	3 x 25	3 x 25	3 x 25
2 legged jumps (with bending knees)	3 x 10	3 x 10	3 x 10	3 x 10	4 x 10	4 x 10
hop with one leg short and quickly	3 x 10	3 x 10	3 x 10	3 x 10	2 x 10	2 x 10
1-legged jumps as high as possible	2 x 8	2 x 8	2 x 8	2 x 8	3 x 8	3 x 8
Sprint from standing	5 x20m	6 *20m	6 *20m	6 *20m	2 x 4*20m	-
Sprint from lying start position						2 x4x10m
	Training session					
Exercise	**7**	**8**	**9**	**10**	**11**	**12**
2 legged jumps (without bending knees)	3 x 30	3 x 30	4 x 20	4 x 20	5 x 20	5 x 20
2 legged jumps as far as possible (with bending knees	3 x 10	3 x 10	4 x 10	4 x 10	4 x 10	4 x 10
Hop with one leg short and quickly	3 x 10	3 x 10	3 x 10	3 x 10	3 x 10	3 x 10
1-legged jumps as high as possible	3 x 10	3 x 10	-	-	-	-
Jump shot without ball	-	-	3 x 5	3 x 5	3 x 5	3 x 5
Sprint from lying start position	5x30m	5x15m	-	-	-	-
Sprint from 5m sideways start	-	-	6x30m	6 x15m	2 x4x30m	2 x4x15m

Table 2. *Training program with the total repetitions per time for strength training group*

	Training session					
Exercise	**1**	**2**	**3**	**4**	**5**	**6**
Squats	3*6	3*6	3*6	3*6	3*6+2.5kg	3*6+2.5kg
Sprint from standing	5 x20m	6 *20m	6 *20m	6 *20m	2 x 4*20m	-
Sprint from lying start position						2 x4x10m
Exercise	**7**	**8**	**9**	**10**	**11**	**12**
Squat	3*6+5kg	3*6+5kg	3*6+7.5kg	3*6+7.5kg	3*6+5kg	3*6+2.5kg
Sprint from lying start position	5x30m	5x15m	-	-	-	-
Sprint from 5m sideways start	-	-	6x30m	6 x15m	2 x4x30m	2 x4x15m

A oneway ANOVA was performed on the anthropometrics and different motor abilities (sprint, strength, endurance, jumps, throws and agility) of the two groups at the pre test. To compare the effects of the training protocols, a mixed design 2 (test occasion: pre-post: repeated measures) x 2 (group: strength vs. plyometrics) analysis of variance (ANOVA) was used. The level of significance was set at $p \leq 0.05$.

Results

After six weeks a significant increase ($p<0.05$) in performance was found for sprint (+2%), agility (+12.2%), 1 m/s weight squat (+29.9%) and running distance at the Yo-Yo IR1 test (27.3%). No significant changes were found for the jumping height (-2.7%) and a significant decrease was found for peak ball throwing velocity (-2.9). No significant differences in changes were found between the groups ($p \geq 0.29$).

Table 2. *Mean (S.D.) performance in the different tests of the strength and jump training groups at the pre- and post test.*

Group	Strength training		Plyometrics training	
Test	**Pretest**	**Post test**	**Pretest**	**Post test**
20m Sprint (s)	5.09±0.37	4.99±0.39*	5.20±0.40	5.1±0.40*
Agility (s)	6.78±0.67	5.91±0.45*	6.53±0.75	5.52±0.54*
7m throw (m/s)	17.0±1.2	16.5±1.3*	18.3±2.9	17.7±2.9*
1 m/s squat (kg)	19.9±11.2	27.5±7.4*	24.4±14.9	29.7±11.4*
CMJ (cm)	35.1±5.3	34.4±5.5	36.3±6.4	35.1±6.7
YoYo IR 1 (m)	843±370	1156±449*	791±410	978±419*

* Indicates a significant difference from the pretest on a p<0.05 level.

Discussion

The purpose of our study was to compare the effect of adding a plyometrics training program with a weight training program to the normal in-season regimen on different motor abilities in adolescent handball players. The main finding was that sprint, agility, strength and endurance performance increased, while there were no differences for jumping height and decrease in throwing velocity with no significant difference in changes between the two groups after the training period.

The increases in performance with sprint and squat strength were in line with earlier studies on young soccer players (Marques et al., 2013a+b). That the throwing velocity decreased was not surprisingly since the subjects did not train extra on this and they were near the end of the season. That the jumping height did not increase was surprising since an earlier study that used the same training program in young soccer players showed increased jumping performances (Marques et al., 2013a). This may be explained through the different movement patterns between training exercise and test exercise and that adolescent handball players already train much on jumping during regular training compared to soccer players. The increased number of jumps would not make a big difference in total for the handball players and thereby not increasing the jumping height during the tests.

Endurance was also increased after the training period, which was surprising, since the subjects did not train specific on endurance. A possible reason for the increase can be due to the conducted endurance test: YoYo IR 1 test. In this test the players have to run 40 m with a turn at 20m, which needs deceleration and acceleration in the legs during the turn. This needs explosive strength. In both training groups the explosive strength was stimulated and shown by the increases in the other motor abilities. In our study we did not use a control group to investigate this effect. However, in earlier studies with the same training programs on the soccer players of the same age (Marques et al. 2013a+b) it was shown that the control group did not get enhancement in the motor abilities. Furthermore, the tests and training was conducted in the end of the competition season in which it is normal that performance level decrease (Granados et al., 2008) and not increases as shown in our study.

No differences in enhancement was found between the groups, which was not hypothesized, since it was expected that the plyometrics training group would enhance more in the different motor abilities. An explanation for this finding could be that the weight training group squatted with relatively small weights (45-50% of 1-RM) with full effort. This is also called power training (Knuttgen & Komi, 1992) which in other studies showed good results on strength enhancement. In addition was the power training combined with some sprinting, which could have a positive transfer from enhanced strength to sprinting. The training was also combined with the regular training and the players started with either the strength or plyometrics before conducting the rest of the regular training. The effects of these two trainings could have a post activation potentiation effect (PAP) on the rest of the training and increase the performance in the rest of the training. Thereby the training effect on the other motor abilities like agility and endurance could have been influenced positively. The strength training group has never trained with weights before, which may lead to sudden positive effect in performance. Furthermore, the new metabolic stress and mechanical drag may lead to positive performance effect for the strength training group. More studies that study the acute effect of these two types of training should be performed before we can state if also the regular training is affected by these training types.

Conclusion

It was indicated in our study that 6 weeks of supplementary plyometrics or weight training (2-legged squats) in adolescent handball players in the end of the competition season can enhance the motor abilities: leg strength, sprint, agility, and endurance, while it did not enhance jump strength and throwing ability. It seems that training 2-legged squats with weights of 45-50% of 1-RM (Power training) have the same effects on these motor abilities and that they both could be included to regular training sessions for adolescent handball players.

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CHARACTER OF TRAUMATISM DYNAMICS IN FEMALE HANDBALL

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Handball is one of sports for which the wide range of various sports traumas is characteristic. The traumatism problem in female handball for many years remains very actual. The traumas got by handballers at the first stages of long-term preparation, much of them bar the way to high sporting achievements. Therefore, studying of specific and typical localization of the injuryies got by handballers at different stages of long-term sports improvement, opens opportunities to creation of system of complex preventive actions.

The Russian handballers (n=120) took part in research aged from 14 till 27 and more years. The most characteristic traumas got by players in the period of training and during competitions were studied. The main reasons and factors of emergence of traumas are established.

Sports injury - damage, accompanied by changes in the anatomical structures and functions of the body injured by the impact of a physical factor that exceeds the strength of the physiological tissue during physical exercise. Injuries - the ordeal for the athlete both psychological and physical nature. Even with the favorable outcome of a serious injury, many children and teenagers discourages exercise. In addition, 10.8% of severe injuries resulting in loss of total disability and sport, that is, lead to disability. Sports injuries are a career break 60-70% of professional athletes (and promising athletes at the peak of his head), the value of their many years of dedicated and extremely hard work.

Every year in the sphere of sports is a progressive increase in the volume and intensity of training loads are increasing demands on the technical complexity and speed of movement is growing psycho-emotional intensity of competitive struggle. However, the steadily increasing number of specific lesions of the musculoskeletal system and chronic diseases, which are often not only become a cause of long breaks in training, but also make athletes prematurely end the exercise. The survey team handball players qualifications showed that because of the injuries they sustain traffic from 7 to 45% of training sessions, 5 to 35% of competitive starts. Serious injury connective tissue leads to the fact that even with the successful treatment and recovery, it can recover after 12 months only 80% of its structural and biomechanical integrity. However, about one third of sports injuries are the result of inefficient rehabilitation after earlier injuries.

Although the causes and mechanisms of injury in handball, symptoms, diagnosis and treatment are known, however, the number of injuries has been steadily growing. This is due to the lack of detectability of injuries and lack of prevention. Usually in handball injury record only if the athlete after it forced to miss the next training session or a competetive game.

Numerous studies on injuries in handball indicate that handball is one of dramatic sports. These researchers suggest that the high rate of injury is typical for players of handball and men's and women's teams.

According to E.G. Pavlova on injuries in handball is known that the most common injury (48%) of the injuries, followed by sprains (28- 52%) and fractures (5-12%). Most affected brush (49%), then the ankle (16%), knee (5%) and second (5%) joints. According the author, 70% of injuries caused by contact between the players.

In studies Strikalenko E.A. (2013) found that the greatest number of injuries Ukrainian handball players have to damage the upper (38%) and lower (26%) limbs. The distribution of injuries among players of different game role following: the 26% pivots, goalkeepers - 24%, wings - 20%, centers (14%) and back courts (16 %). In the current study 's also found that 63.2% of athletes using a conservative treatment, and 36.8% used handball players operative treatment. From this it follows that the most frequently injured players line leading constant and active resistance with a rival.

The data of Ukrainian researchers disagree with the data of Russian investigators - Ignatevoj VY, Petrachevoy IV, Ignatieff AA Their studies show that among the Russian handball goalkeepers most often injured - one handball team had 9.2 injuries. This is a very high figure. Quite a lot of injuries get wings - 7.7 and back court players - 7.5. Less often receive damage pivots - 6.4 and centers - 5.5.

A study in Sweden for 12 seasons, has allowed researchers to record the main injuries sustained major league players. Typical injuries Swedish handball players are also a knee injury, ankle, shoulder and hand. In this case, the players are forced to miss and training sessions and competitions due to treatment.

Patterns of injuries in women's handball

Handball is a contact game. About 40% of injuries caused by collisions of players 30% damage handball players get during the run (speed, feints, sudden stops and turns). The number of injuries is slightly higher during the competitive games than during the workout, which is associated with a high level of motivation to achieve victory, and, as a consequence - increased rigidity of the game, a considerable degree of mental stress athletes prone to aggression. Between stress and the occurrence of injury is a direct relationship. Muscular tension increases in response to stress, resulting in reduced flexibility and muscle loss of motor coordination. Physical fatigue can impair concentration, increasing the potential risk of injury.

From the age of 14-16 years, the growth of the number of injuries is parallel to the growth of skill athlete. Morpho-functional immaturity of the osteoarticular system adolescents is a base for development of instabilities, biomechanical dysfunctions. Most often, the functional asymmetry observed in the hip adductor muscles. Maximum peak of injuries involve the third month of the season. Muscle damage up to 30%, sprain - up to 20%, of which - 44% of the injuries of moderate severity, and 23% - heavy. The main localization - hip, knee, ankle (with 58%).

The most traumatic in handball age - 18-19 years. At this age, players often do not have the proper level of physical conditions. Continues to improve the musculoskeletal system at the same time the development of large-volume and intensity training and competitive pressures. Young players are very emotional, which also increases the risk of injury. A high level of flexibility helps reduce the likelihood of injury, but the lack of basic game experience, lack of professionalism increase it significantly. Number of injuries in the second half of approximately 50% greater than the first. Researchers in this regard emphasize the role of physical fatigue as a factor predisposing to injury.

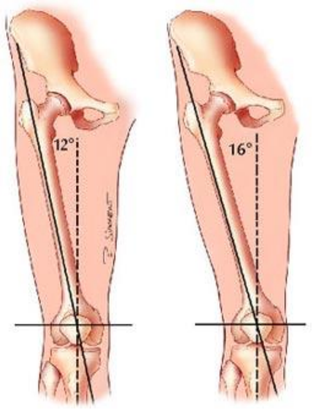
Women handball injured virtually no less frequently than men. Researchers are various reasons for the high injury rates. Women are less well developed muscles, the muscles and ligaments are more vulnerable to injuries structure. Among other reasons - increase the intensity of the game, the demonstration close to the male power play style is quite common features of sport brutality.

Throughout the world, scientists worried about the problem of sports training for women - high-class athletes. Features of the female body cause a number of characteristic features of women in the construction of motor actions through years of playing sports.

According to J.M. Kotz (1986) it is known that some differences morfofunkcional female body from males (body size, especially muscle and fat components) cause less than men possible manifestations motor mechanically force of mechanical work and its capacity. In women, even under the influence of special training are smaller increase power capabilities. In women less than the total number of fosfagenov, the capacity of anaerobic glycolytic system, which significantly limitruet manifestation of submaximal power. Furthermore, for the female body characterized by low capacity supply to exhibit aerobic efficiency (maximum oxygen consumption, the concentration of hemoglobin in the blood, its oxygen capacity, blood volume, etc.).

Sports medicine specialists say some anatomical features of the woman's body, correct at high risk of sports injuries. For example, an injury anterior cruciate ligament is one of the most common injuries in sports in general. According to the review of Steve Bollène ACL injury, even ahead of the frequency of meniscal injury (Bollen S., 2000). According to European research in women's handball at 8 times more likely to injure the anterior cruciate ligament than men. There are several explanations for this fact:

1. Front angle between the femur and tibia (Fig. 1) - men - 12˚, women - 16˚.



2. Intercondylar notch width - women narrower notch than men, which severely limits the space for the movement of the bunch.
3. The strength of the thigh muscles - women are less well developed muscular strength in proportion to the size of the bones than men.
4. The consistency of the antagonist muscles thigh - the quadriceps femoris and hamstrings women work differently than men, with a bent knee female quadriceps reduced stronger, which puts forward leg, creating a greater risk of anterior cruciate ligament injury, at the same time, the hamstrings muscles react more slowly than men, these muscles prevent the shifting of the tibia forward relative to the femur.

5. The hormonal profile - female hormones, according to the researchers, may influence the composition and mechanical properties of the anterior cruciate ligament, and the elasticity of the muscles and tendons surrounding then knee.

The basis of the origin of any sports injuries are certain subjective and objective factors , each of which can be made a condition of a fault or proximate cause.

Analysis of results

In the etiology of sports injuries, as well as any other form of disease, which is closely intertwined internal and external factors, each of which may in some cases cause damage, while in others - a condition of its occurrence. Often, external factors, causing certain changes in the body, creating the internal cause that leads to injury.

The competition women receive 56% of the total number of injured. In this case, more than 40% of all women get damaged by contact with the players of the opposing team. In training, injury has a slightly different picture (44%). After contact handball were injured in 17% of cases, through their own fault - 26%. The greatest amount of damage to all authors in the course of our study researches occupy (49% of all the injuries), upper extremity injuries. Considered very hands athletes: sprains and fractures account for up to 32-36% of all injuries received by the upper limbs , 14-16% of the damage suffered elbow. In this case, Norwegian experts (G. Myklebust, L. Hasslan, R. Bahr, K. Steffen, 2013) point out serious problems with the shoulder joint in a large number of players, league teams.

In the lower limbs often injured ankle - 52% of all injuries, 26% - the knee, 17.6% - muscle injuries .

Injuries in female handball players has different tendencies depending on age. Most susceptible to injury, according to Ignatieff AA (Table 1), was the age of 27 years and older. Handball players in this age group had a rate of 9.5 injuries per person. Thus all types of damage different parts of the body parts they have very high (above average) indicators, except the lower limb injuries where they outperformed 6% handball aged 18-21.

Table 1.

Injuries	**14-17 years**	**18-21 years**	**22-26 years**	**27 years and more**
Numbers	6,6	8,9	5,4	9,5

Handball players aged 18 to 21 years were 8.9 injuries per player. They have the highest rate of injuries of the lower extremities - 3.3. Fairly high rate (3.9) account for the players of this age and injury to the upper limbs.

Our research has largely coincide with those of other authors, emphasizing the continuing trend of high female injuries in handball. Injuries handball 14-17 entering the elite sport achievements, remains quite high - 6.9 injuries per person. In this age group handball upper limb up to 48% of all injuries. Recently there has been growth and lower limb injuries - up to 36% of head injury (0.7) - 10%, torso - 6%. This is explained by the increase in the intensity of training loads, a significant increase in competitive practices.

Athletes aged 18-21 was obtained upper limb injuries (42%), injuries of the lower extremities - 40% of head and neck - 12%, torso - 6%.

At the age of 22-26 years old handball players are up to 40% damage to the upper extremities, and 32% - the lower, a relatively high rate of injuries of the head and neck - 18% and trunk - 10%.

At the age of 27 years and older and 44% were injured top limbs (hand, elbow, back joint), 32% - the lower, 16% - for a head injury neck, 8% (0.7) - the body.
Significant injury to fingers are inherent in 18-21 year old handball in a collision with an opponent at the end of the throw and when catching the ball in traffic - 35%. A smaller number of similar injuries get the players 14-17 years of age (26%) and the oldest (24%) of the athletes 22-26 years, the number of injuries slightly (9%). The elbow joint in 42% of cases, the injured player to the oldest age, up to 26% of the injuries happen to the players 14-17 years old. The shoulder joint is most often (45%) injured in the most senior handball players, 26% of injuries between the ages 18-21 years, 19% - for players under 17 years of age and only 10% for female athletes between the ages of 22 to 26 years. Bruises and abrasions in the largest number of players get 22-26 years - 35%. Athletes 18-21 years of age and over 27 years of age receive 25% of this type of injury, and the youngest 15% of the total number of injuries. Most injuries of lower limb muscles get the players age 27 and over (1.4), then (0.8) - handball players aged 18-21 years, then 14-17 years (0.7) and 22-26 years (0.4). Ankle and knee joints produced the greatest number of injuries in female athletes 18-21 years (0.8 to 1).

Conclusions
Found that the highest percentage of non-return to an active handball competitive activities after the tears and tears of the ligaments - every third athlete, after the removal of the meniscus - one in four, after concussions are not returned to the elite sport every fifth handballes.

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THE RELATION BETWEEN PERCENTAGES OF BODY FAT AND MEASURES OF RUNNING SPEED, JUMP POWER, RSA AND VO2max CONSUMPTION IN SLOVENIAN FEMALE SENIOR ELITE HANDBALL PLAYERS

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Summary
We tried to found out correlations between percentage of body fat and measures of running speed, jump power, RSA and VO_{2max} consumption indicator. The subjects were 17 elite slovenian senior woman players. Descriptive statistics were computed. Correlations were established by Pearson corelation coeffitiens. We may conclude that jump power indicators, RSA and VO2max consumption are in a significant negative relationship with the percentage of body fat tissue. But we couldn't proved the significant relationship between body fat values and results obtained in sprint tests.

Keywords
Woman elite handball, body fat, motoric

Introduction

The physical part of a team handball game consists of a combination of intense, intermittent activities such as running, sprinting, jumping as well as regular struggles between players – holding and pushing (Jensen, Johansen, & Liwendahl, 1999). Morphological characteristics of the body and motor abilities certainly have a great influence on an outstanding performance in handball (Jensen, Johansen & Larsson, 1999; Šibila, & Pori, 2009, Mohamed, et al., 2009). That is particularly typical of top handball, where the advantages of players with a suitable morphological and motor structure are evident (Rannou, Prioux, Zouhal, Gratas-Delamarche, & Delamarche, 2001). Recent research studies dealing with the morphological profile of female top-level handball players highlighted that they are characterised by a prevailing mesomorphic somatotype with a touch of endomorphy, that is, with a pronounced adipose tissue (Vila, et al., 2012). In terms of handball players' motor structure, the most prominent are the explosive and elastic power of the legs, arms and shoulder girdle, agility, sprint speed and specific aerobic endurance (Šibila, 1989; Jensen, Johansen, & Liwendahl, 1999). Many researchers proved that excessive amounts of subcutaneous fat by the top level athletes is negatively correlated with the results achieved in the tests of specific motor abilities and with indicators of aerobic resistance (Houtkooper, Mullins, Going, Brown, & Lohman, 2001; Klossner, 2007; Šibila, Bon, Mohorič & Pori, 2011; Montcef, Said, Olfa & Dagbaji, 2012). Alongside regular monitoring of the anthropometric characteristics and motor abilities by the woman slovenian elite handball players we recongnized that a share of body fat increase. That's way we tried to found out correlations between percentage of body fat and measures of running speed, jump power and VO_{2max} consumption indicator.

Methods

Sample

The subjects were 17 elite slovenian senior female players which participate in regular testing of A-senior national team. The measurements were carried out in 2010. At the time of measurement, the study subjects were 22.9±5.04 years old on average. Their average body height was 177.2±4.68 cm and body mass 66.5±7.56 kg.

Variables

The assessment of subject's subcutaneous fat value (percentage of body fat) was calculated from 9 skin fold measures based on the standard anthropometric battery with 24 dimensions (Duquet, & Hebbelinck,1977). The assessment of the explosive and elastic power of the legs was made using the tensiometric platform; the study subjects performed two different jumps: a squat jump (SJ) and a counter movement jump (CMJ). The ability to generate sprint speed was assessed using sprint times over 5, 10 and 20 m with a standing start (T5m, T10m and T20m) and a flying start (FT5m, FT10m and FT20m). Repeated sprint ability was assessed with a 40-m maximal shuttle run test (40-m MST) (Baker, Ramsbottom, & Hazeldine, 1993). It's a multiple sprint tests incorporating changes of direction. Subjects completed one trial of the 40-m MST (8 × 40-m; 20 s rest periods). We took into consideration a sum of time obtained in all eight repetitions. Running endurance was assessed using the 30-15IFT test (Buchheit, 2005a; Buchheit, 2005b). This is an intermittent fitness test (with interruptions) performed on a handball court – 30 s of running and 15 s of rest. The subjects were running at a pace dictated by a sound signal. The running speed increased with each repetition and the runners persevered until exhaustion or so long as they were capable of running the specific distance foreseen in the interval. The obtained result enables the approximate maximum use of oxygen to be calculated using the following formula: VO2max(ml/min/kg) = 28.3 – 2.15 * G – 0.741 * A – 0.0357 * P + 0.0586 * A * V + 1.03 * V, where: G is gender (1 = male, 2 = female), A is age, P is weight and V is the final velocity recorded in the test. All measurements were conducted by the same people, using the same measurement technology.

Table1: *Sample of variables*

Test	Measured capacity	Measuring unit
% of body fat	Amount of body fat	%
5-m sprint – standing start	Sprint speed	Seconds
10-m sprint – standing start	Sprint speed	Seconds
20-m sprint – standing start	Sprint speed	Seconds
5-m sprint – flying start	Sprint speed	Seconds
10-m sprint – flying start	Sprint speed	Seconds
20-m sprint – flying start	Sprint speed	Seconds
40-m MSTmean	Anaerobic capacity	Seconds
VO_2max	Maximal O_2 consumption	ml/min/kg
Squat Jump	Explosive power of leg	Cm
Counter Movement Jump	Elastic power of leg	Cm

Data analysis

The data were analysed using the statistical package SPSS 20.0. Basic parameters of the distribution of variables were calculated (mean, standard deviation, minimum and maximum values, kurtosis, skewness and Kolmogorov-Smirnov test of normality). Pearson Correlation Coefficient) was used to test the degree of correlation among the variables. A probability level of 0.01 or less and 0.05 or less was taken to indicate significance.

Results

Table 2 presents the basic statistical characteristics of body height, body mas, % of body fat and selected motor parameters. The table shows average values, standard deviations, minimum and maximum values, kurtosis, skewness and significance of the Kolmogorov-Smirnov test.

Table 2: *Basic statistical characteristics of all parameters*

Parameter	$\bar{x}$	S	min	max	kurt	skew	pK-S
Age	22.9	5.04	19.0	36.0			
BH	177.2	4.68	166.6	182.2			
BM	66.5	7.56	64.6	94.7			
%FM	22,53	3,2036	17,0	29,0	-,327	,517	,133
T_{5m}	1,22	,06276	1,14	1,35	-,813	,019	,200
T_{10m}	2,05	,07894	1,91	2,24	1,111	,603	,200
T_{20m}	3,50	,14069	3,28	3,79	-,434	,548	,146
TF_{5m}	,77	,03520	,71	,83	-,808	,376	,200
TF_{10m}	1,47	,07612	1,35	1,60	-1,076	,008	,200
TF_{20m}	2,84	,14595	2,60	3,12	-,851	,099	,200
40-m MST	74,55	3,05769	71,17	81,26	,637	1,090	,106
VO_{2max}	45,74	3,27244	37,07	48,59	2,430	-1,701	,004
SJ	27,33	3,68	20,6	32,5	-1,410	-,252	,200
CMJ	27,88	3,27	23,1	33,1	-1,421	-,110	,200

Legend: $\bar{x}$ - average values; s - standard deviations; min – minimum values; max - maximum values; kurt – kurtosis; skew – skewness; pK-S – significance of the Kolmogorov-Smirnov test; BH - Body height; BM - Body mass; %FM - Amount of body fat; T_{5m} - 5-m sprint – standing start; T_{10m} - 10-m sprint – standing start; T_{20m} - 20-m sprint – standing start; TF_{5m} - 5-m sprint – flying start; TF_{10m} - 10-m sprint – flying start; TF_{20m} - 20-m sprint – flying start; 40-m MST ; VO_{2max} - Maximal O_2 consumption; SJ - Squat Jump; CMJ - Counter Movement Jump.

The data reveal that all measured parameters, with exception of VO_{2max}, are normally distributed.

Table 3 show the results of Pearson Correlation coefficients based on which we established whether there were any statistically significant relationships among percent of body fat value and results in motoric tests. In the table we placed also the coefficients that show the correlation between motor variables themselves.

Table 3: *Values of Pearson Correlation coefficients among all variables*

	%FM	T_{5m}	T_{10m}	T_{20m}	TF_{5m}	TF_{10m}	TF_{20m}	40-m	Vo_{2max}	SJ	CMJ
%FM	1.000	-,034	,039	-,021	,056	-,184	-,167	-,575*	-,685**	-,629**	-,509*
T_{5m}	-,034	1.000	,729	,845	,400	,333	,558	,429	,319	,456	,389
T_{10m}	,039	,729	1.000	,797	,716	,813	,697	,475	,435	,624	,547
T_{20m}	-,021	,845	,797	1.000	,639	,547	,857	,573	,382	,587	,553
TF_{5m}	,056	,400	,716	,639	1.000	,797	,770	,654	,330	,537	,534
TF_{10m}	-,184	,333	,813	,547	,797	1.000	,722	698	,421	,607	,548
TF_{20m}	-,167	,558	,697	,857	,770	,722	1.000	,747	,388	,591	,610
40-m	-,575*	,429	,475	,537	,654	,698	,747	1.000	,833	,837	,735
Vo_{2max}	-,685**	,319	,435	,382	,330	,421	,388	,833	1.000	,340	,239
SJ	-,629**	,456	,624	,587	,537	,607	,591	,837	,340	1.000	,727
CMJ	-,509*	,389	,547	,553	,534	,548	,610	,735	,239	,727	1.000

Discussion and Conclusions

We may conclude from our study that jump power indicators, result in RSA test and VO_{2max} consumption are in a significant negative relationship with the percentage of body fat tissue. But we couldn't proved the significant relationship between body fat values and results obtained in sprint tests. In the literature we can find similar findings - excessive fat mass may negatively affect an athlete's flexibility, power, speed, agility, and aerobic capacity (Houtkooper, et al. 2001; Klossner, 2007). Some researchers revealed (Castro-Pinero, Gonzales-Montesinos, Keating, Mora, Sjostrom, & Ruiz, 2010), weight status (and body fat level) could have a significant influence on sport performance. It's also stated in some researches of male handball players (Moncef, et al., 2012) that weight is negatively correlated to the squat jump and the countermovement jump performance, weight, and body composition measures (fat and thin body mass) are additionally negatively related to the maximal oxygen uptake, and to the maximal velocity obtained in the Yo-Yo recovery test. Many other studies have shown that relative VO_{2max} is negatively correlated to body mass (Berg, Sjødin, Forsberg, & Svedenhag, 1991). Most researchers agree that physical performance may be highly associated with body composition (Lucia, Hoyos Perez, Santalla & Chicharro 2002; Chaouachi, Brughelli, Levin, Boudhina, Cronin, & Chamari, 2009; Šibila, &, Pori, 2009). This is supported by the fact that more fat mass constitute a "dead mass" which the player must lift up (Godek, Godek, & Bartolozzi, 2004). Findings in recent studies dealing with the female handball players are also in line with this theory. Vila et al (Vila et al., 2012) present the data which shove that centers and wings have lower weight and sum of skinfolds than backs, pivots and goalkeepers (even if this differences were not significant). Accordingly with this centers and wings achieved better results in SJ and CJM in comparison with backs, pivots and goalkeepers (also these results are not statistically significant).

Optimal competitive body weight and share of body fat varies between athletes, sports, and positions (Gibson, Mermier, Wilmerding, Bentzur, & McKinnon, 2009). It's also the fact that overweight in athletes appear especially in sports, in which body size and body mass are important, e.g. football, sumo, weight-lifting, and in which body components can affect physical performance, beyond body size and advancement level. Those factors have been identified as predictors of performance and selection in a number of sports (Gibson, et al., 2009). Similarly, of course, also applies to handball where weight is extremely important success factor especially at the pivot position. But the negative relationship between increased body fat percent and achievements in the important motor tests for players from our sample suggests that reducing body fat is necessary for progress in the sports performance in handball. Following our findings coaches should instruct players to reduce redudant body fat tissue by appropriate diet and training. It can be assumed that this would positive affect the results in motor skills that are important for successful playing handball.

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STUDY OF THE PHYSICAL CONDITION OF YOUNG ELITE FEMALE HANDBALL PLAYERS

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Summary
The main aim of this study was to determine physical fitness profile of young elite female handball players. A second objective was to establish differences based on their playing positions. Results showed significant differences in all physical fitness tests based on their specific playing positions. In general, wings and first line players (center, left back and right back) obtained the best results, while goalkeepers obtained the worst results.

Keywords
Young female handball players, fitness assessment, physical fitness, playing positions in team handball

Introduction
Team handball is a complex intermittent game, which requires players to have well-developed aerobic and anaerobic capacities (Delamarche et al., 1987; Gorostiaga, Granados, Ibañez, González-Badillo, & Izquierdo, 2006). Motor ability, sprinting, jumping, flexibility and throwing velocity represent physical activities that are considered as important aspects of the game and contribute to the high performance of the team (Granados, Izquierdo, Ibañez, Bonnabau, & Gorostiaga, 2007; Marques & González-Badillo, 2006).

Team positions in team handball can be broadly classified as goalkeepers, first line players and second line players (Pezerat-Correia, Valamantos, Francisco, & Santos, 2007). These positions are: center, back players, wing players, pivots, and goalkeepers. Time motion studies have shown that in the course of the game handball players perform different activities depending on their positions (Cambel, 1985; Sibila, Vuleta, & Pori, 2004). During the game, wings seem to cover the longest total distance and the longest distances while sprinting (Luig, Manchado-Lopez, Perse, Kristan, Schander, Zimmermann, & Platen, 2008; Sibila et al., 2004), while backs seem to execute the largest number of throws (Ohnjec, Vuleta, Milanovic, & Gruic, 2003).

Few studies have realized comparisons between physical fitness characteristics based on specific playing positions in team handball. In addition, few studies has investigated whether there are any differences among playing positions at young age, when athletes begin to specialize in playing positions (Zapartidis, Toganidis, et al., 2009). The aim of the present study was a) to determine the physical fitness profile of female young elite handball players and b) to establish the differences based on their game location.

Additionally, results from motor performance tests will allow trainers to identify players´ weaknesses and design training models for improving specific athletes´ deficiencies, but also follow up the athlete´s improvement during a competitive season. Furthermore, the data of the present study could be added in the international literature and assist in talent identification and development.

Methods

Participants

The total sample consisted of 137 young elite female handball players from 13 to 16 years (M= 14,25; SD= 0,74), which have been playing a mean of 8,66 years (SD=2,16), and a mean of 5,10 years competing (SD=2,18). All players competed in the highest league of their sports category, were selected as the best players of their sport category, belonged to the National Sporting Talent Programme of the Royal Spanish Handball Federation, and commonly performed at least 3 training sessions per week plus one official match.

All players and their parents were informed about the procedures of the measurements and provided their written consent for participating according to the research policy of the Royal Spanish Handball Federation.

Procedure

Six variables were recorder for each young female handball player. These included aerobic capacity (VO_{2max}), explosive power of the lower limbs, throwing velocity, agility and running speed. For motivational purposes, the players were immediately informed of their performance in all tests.

Aerobic capacity was expressed as estimated maximal oxygen uptake using a 20m shuttle run test (Course Navette) and predicted by a regression equation according to the age and the running speed at the last completed stage (Leger, Mercier, Gadoury, & Lambert, 1988). The subjects completed only one attempts of this test.

For *Long jump test*, players were placed in a static position behind a line and they must jump pushing forward with both legs at the same time as far as they could, allowing them countermovement of arms and legs.

For *Squat jump test* was used an Ergo Jump Bosco/System®, where was calculated jump height from flight time on a contact platform, using a microcomputer Posion Organiser II (with accuracy of 0,001 sec.). The players started with their hands on their hips and knees bent at 90º and without previous countermovement jumped upward. The players completed 2 attempts of each type of jump, and the better of each one was used for the subsequent statistical analysis. Between jumps, the participants were allowed to recover for 3 minutes to avoid fatigue.

Throwing velocity was measured using a radar gun (Pocket Radar™ Personal Speed Radar Gun). Evaluator with the pocket radar in his hand was placed behind the standard goal of handball and in a perpendicular direction to the thrower. The female handball players threw a standard ball of handball as fast as possible towards the goal without goalkeeper, using dominant hand and their personal technique. The sequence of throwing was as follows: a 3-step running throw from the 9-m line, and a 3-step running throw from the 9-m line with a jump. Three throws of each type were performed, and the best trial was used for further analysis. A 3-minute rest elapsed between throws to avoid fatigue.

To evaluate the *Running speed* was measured the time taken to run 30 meters using two pairs of photoelectric cells (AFR System ®), interconnected to an accountant Seiko System Stop Watch S129, with a precision of 0,01 seconds. The test consisted in a 30-m sprint, starting from a static position and standing. The players began to run when they wanted and at that moment the first photocells gate were automatically activated. They had to run 30m as fast as possible until passing the finish line where the second photocells gate was placed. The participants performed twice the 30-m sprint and the best one mark was used for the subsequent statistical analysis. Between each sprint were allowed 3 minutes of rest to avoid fatigue.

For *Illinois agility test*, players had to run a circuit race that occupied an area of 10 m long by 5 m wide, where four cones were used to mark the start, finish and the two turning points. Another four cones were placed down the center an equal distance apart. Each cone in the center was spaced 3,3 meters apart. Athlete must be placed lying on his front (head to the start line) and hands by his shoulders. On the “ready, steady, go” command the stopwatch started to run, and the athlete had to get up as quickly as possible and run around the circuit in the direction indicated, without knocking the cones over, to the finish line, where the timing was stopped. The fastest value obtained from two attempts with 3min recovery in-between was used as the agility score.

Data analysis

Standard statistical methods were used to calculate the mean and SDs. All data are expressed as mean (SD), minimum and maximum (all data were checked for distribution normality and homogeneity with the Kolmogorov-Smirnov and Lilliefors tests). Differences in physical fitness profile based on playing positions were compared using a one-way analysis of variance using Scheffe´s post-hoc test. Statistical significance was set at $p \leq 0,05$. The results were analyzed using SPSS software, version 17.0.

Results

Descriptive statistics for physical fitness profile for all young female handball players are presented in Table 1.

Table 1. Physical fitness profile of young elite female handball players (N=137).

	Mean (SD)	**Min.**	**Max.**	**Centiles**						
				5	**10**	**25**	**50**	**75**	**90**	**95**
30-m sprint (sec)	5,01 (0,30)	4,37	6,29	4,60	4,66	4,80	4,98	5,17	5,37	5,59
Squat jump (cm)	31,78 (5,66)	13,50	45,00	22,30	25	28	32	36	38	41
Long jump (m)	1,77 (0,21)	0,98	2,30	1,41	1,50	1,62	1,80	1,90	2,03	2,10
Throwing vel. ($Km.h^{-1}$) (3-step running)	68,66 (6,25)	48	84	57,80	59,80	65	69	72	76,20	79
Throwing vel. ($Km.h^{-1}$) (3-step running with a jump)	69,58 (5,74)	52	80	58,70	61	67	70	73	77	78,10
VO_{2max} ($ml.kg^{-1}.min^{-1}$)	45,60 (3,94)	32,27	55,73	39,53	40,60	42,23	46,15	47,63	50,33	50,74
Illinois agility test (sec)	19,76 (1,46)	17,25	27,07	17,96	18,30	18,85	19,41	20,37	21,44	22,44

Table 2 shows the differences in physical fitness characteristics between positions as obtained by the post-hoc test.

30m sprints: Centers and wings showed higher velocity values than do backs ($p<0,05$), pivots ($p<0,01$) and goalkeepers ($p<0,01$). However, no significant differences in 30m sprints were found between centers and wings.

Squat jump test: Centers showed best performance among all players with significant differences from goalkeepers ($p<0,05$). Wings performed better than backs, pivots and goalkeepers with significant differences from goalkeepers ($p<0,01$). Backs on average performed better than pivots and goalkeepers but without significant differences.

Long jump: Centers and wings best performance among all players with significant difference from pivots ($p<0,01$) and goalkeepers ($p<0,01$). Backs performed better than pivots and goalkeepers with significant differences from goalkeepers ($p<0,01$). Goalkeepers showed the worst standing long jump values.

Throwing velocity (3-step running throw from the 9-m line): centers players achieved the highest values of all players while goalkeepers had the lowest scores, with significant differences only between both positions ($p<0,01$).

Throwing velocity (3-step running throw with a jump from the 9-m line): we were found significantly different with regard to play positions, where goalkeepers obtained poor results ($p<0, 01$).

Estimated VO_{2max}: centers and wings showed best performance among all players with significant difference from goalkeepers ($p<0,01$). Backs performed better than pivots and goalkeepers but without significant differences.

Illinois agility test: centers and wings showed best performance among all players with significant difference from pivots ($p<0,01$) and goalkeepers ($p<0,01$). Backs on average performed better than pivots and goalkeepers with significant differences from goalkeepers ($p<0,05$).

Table 2. Mean score (SD) of running speed, explosive power of the lower limbs, ball velocity, aerobic capacity and agility of young female handball players according to their playing position.

Test/Specific playing positions	**(C)Center (N=22) Mean (SD)**	**(B)Backs (N=40) Mean (SD)**	**(W)Wings (N=30) Mean (SD)**	**(P)Pivots (N=25) Mean (SD)**	**(G)Goalkeepers (N=20) Mean (SD)**
30-m sprint (sec)	4,81(0,19)^{BPG} [4,45-5,09]	5,04(0,22)^{CW} [4,67-5,63]	4,83(0,22)^{BPG} [4,37-5,33]	5,17(0,38)^{CW} [4,68-6,29]	5,20(0,32)^{CW} [4,83-6,02]
Squat jump (cm)	34,26(4,38)^{G} [25,9-43,00]	31,25(5,18) [21,4-41,00]	34,12(5,67)^{G} [23,9-45,00]	30,22(4,78)] [19,00-40,00]	28,46(6,64)^{CW} [13,5-41,00]
Long jump (m)	1,88(0,15)^{PG} [1,48-2,12]	1,79(0,18)^{G} [1,48-2,17]	1,84(0,19)^{PG} [1,38-2,30]	1,66(0,20)^{CW} [0,98-1,98]	1,61(0,19)^{CBW} [1,26-2,00]
Throwing velocity (Km.h^{-1}) (3-step running)	70,77(6,11)^{G} [55-80]	69,25(5,26) [59-79]	69,60(6,86) [48-84]	68,32(6,47) [55-79]	64,20(5,36)^{C} [55-72]
Throwing velocity (Km.h^{-1}) (3-step and jump)	71,23(4,24)^{G} [61-79]	71,10(4,33)^{G} [59-80]	70,43(5,72)^{G} [55-79]	69,72(5,86)^{G} [56-80]	63,25(5,72)^{CBWP} [52-73]
VO_{2max} (ml.kg^{-1}.min^{-1})	47,36(3,48)^{G} [40,60-55,73]	45,91(2,71) [39,54-50,33]	46,52(3,61)^{G} [40,60-55,73]	44,58(4,76) [34,14-53,03]	41,68(4,28)^{CW} [32,27-50,33]
Illinois Agility Test (sec)	18,88(0,72)^{PG} [17,72-21,35]	19,76(0,92)^{G} [17,81-22,38]	18,93(0,93)^{PG} [17,25-21,87]	20,70(1,67)^{CW} [18,66-24,90]	20,87(1,98)^{CBW} [18,28-20,07]

^{C} Significantly different from centers. ^{B} Significantly different from backs. ^{W} Significantly different from wings. ^{P} Significantly different from pivots. ^{G} Significantly different from goalkeepers.

Discussion

Despite the importance of physical fitness has on performance in handball, few studies have studied this matter in this age group. The aim of the present study was to determine the physical fitness profile of young elite female handball players and to establish the differences based on their playing positions. This is a very important issue because there are few studies on the differences in physical fitness profile in young elite female Spanish handball players. This article contains new information about young elite female handball players by specific playing positions that could be extremely useful for coaches.

Previous literature has been reported similar results to those found in our study except in squat jump test and throwing velocity test (Civar, 2012; Zapartidis, Toganidis, et al., 2009; Zapartidis, Vareltzis, Gouvali, & Korocos, 2009). Nevertheless, interpretation of these comparisons should be made with care because there are few studies published and methodologies and sample levels are also different.

The present study found that centers and wings were significantly faster than backs, pivots and goalkeepers. In addition, backs showed superiority, although not significant to pivots and goalkeepers. These findings are in agreement with previous studies (Rogulj, Srhoj, Nazor, Srhoj, & Cavala, 2005; Sibila et al., 2004), which have found that wings are the fastest players of elite male and female teams. However, the results obtained by centers are not agreed with those found in other studies (Civar, 2012; Zapartidis, Toganidis, et al., 2009; Zapartidis, Vareltzis, et al., 2009). Sprinting velocity for short distances is an important element of performance in team handball. Players are required to cover distances between 20-30 m with maximal speed from the phase of attack to the phase of defense after a ball loss, or in order to run a fast break. Wings participate in such moves commonly. Studies have shown than wings spend 18% and 4% of the total playing time running faster than 3,5 m/s and 5,2 m/s, respectively (Sibila et al., 2004). These finding suggest a greater requirement for acceleration and sprint in wings that the other players.

Standing long jump test and squat jump test are available tests for evaluating the ability to achieve high muscular force very quickly, which is very importance in team handball. Our players exhibit similar values in standing long jump compared other players with a similar age (Lidor et al., 2005; Zapartidis, Toganidis, et al., 2009; Zapartidis, Vareltzis, et al., 2009). Centers and wings showed significant differences with respect to pivots and goalkeepers. Wings perform throwing with jump forwards in an effort to reach the goalpost as closely as possible, either from the position they have in the game, or at the end of a counter-attack. These actions are performed by other players as well, but, with a considerably lesser extend and intensity (Rogulj et al., 2005). In fact, during the phase of attack, wings move in a limited space of 2-3 meters and require a greater ability to generate great force rapidly.

The squat jump mean scores of our players are lower than those previously reported (Civar, 2012). Significant differences were found in vertical jump (SJ) among specific playing positions in our sample, where centers and wings showed significant differences with respect to goalkeepers. Unluckily, we have no found data concerning squat jump according to handball player´s position to compare our results.

In the present study, centers showed a significantly higher velocity in throwing the ball with 3-step running from the 9 m line than goalkeepers. On the other hand, goalkeepers showed statistical significance in throwing the ball with 3 steps running from the 9 m line with jump over all other positions. Unfortunately, there are no studies using our throwing velocity test to which compare our results with the same group of age.

Players of team handball required a high aerobic uptake (between 4-6,5 km per game) depending on the player´s positions and the competitive level of the teams (Luig, Manchado-Lopez, Perse, Kristan, Schander, Zimmermann, Henke, et al., 2008; Pers, Bon, Kovacic, Sibila, & Dezman, 2002; Sibila et al., 2004). The present study found that centers and wings had greater estimated VO_{2max} than all other playing positions, with significant differences from goalkeepers. These finding are also in agreement with a previous study (Zapartidis, Toganidis, et al., 2009) which reported similar VO_{2max} performance among playing positions, with centers and wings showing significantly higher values than goalkeepers. In addition, it has been reported that wings cover significantly greater total distance during the game than other players, whereas goalkeepers cover the smallest total distance (Luig, Manchado-Lopez, Perse, Kristan, Schander, Zimmermann, Henke, et al., 2008; Sibila et al., 2004). High aerobic fitness is important for wings, as they are the players who perform the most picks and require high levels of aerobic capacity to aid recovery after high-intensity sprint.

The mean scores obtained in Illinois agility test by our players are in line with those previously reported in other sports (BenOunis et al., 2013). Nevertheless it is difficult to compare the current results according to player´s positions with other studies, as there are few data for similar age in handball players.

Conclusions

The present study compared physical fitness profile with to specific playing position of young elite female handball players. The results showed differences in physical fitness profile between playing positions. Above results can prove to be extremely useful for coaches and trainers, as they are based on tests that reflect the specific characteristics of individual playing positions. More profiling studies of young elite female handball players are required in order to obtain normative data. These finding could be added to the international literature and assist in talent identification and development.

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THE RELATIONSHIP BETWEEN CHOSEN FACTORS OF PLAYING PERFORMANCE AND THE LENGTH OF ACTIVE CAREER OF AN ACTIVE CAREER OF FEMALE HANDBALL PLAYERS

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Summary
The aim of the study was to find out possible effects of career length on selected factors of playing performance. We used a correlation method to determine the relationship between career length and selected factors of playing performance. Career length has an influence on two factors of playing performance – the number of stolen balls and also the number of turn overs. There is only one team in which career length has an influence on the results of the team.

Keywords
Career length, playing performance, European Championships

Introduction
Evaluation of playing performance is one of the most important methods of gathering data not only for a team´s sports preparation, but also for further fields of the development of handball (keeping in touch with development trends, description of skills within the range of handball theory etc.) In principle, there are two basic types of playing performance – individual and team one. Team playing performance is correlative with not just the quantity and quality of individual playing performances, but also with their mutual relations. In both types, their basic features are considered to be: non-standard match conditions, a large amount of motor skills and motor structures, variability, creative combinations, anticipation, the choice of solutions in changeable playing situations, fulfillment of tasks within the range of individual functions in the team.

The above-mentioned facts suggest that the demands on the quantity and quality of skills and knowledge of individual players as well as teams are high and learning them requires sufficient amount of time filled with training process and games. In this connection, the term very often applied is „playing experience“or its equivalents. On international level, the number of played international games is often considered to be the index of experience. It is naturally connected with the age of the participants of top competitions, as it is automatically presumed that a higher age means a higher number of played matches and thus also more experience, but there is a connection with the length of the player´s active career as well. So the personal make-up of a team might be a factor that influences the playing performance of a team not only in a single match, but in a long-term competition as well.

In professional debates, playing experience expressed by means of the length of a player´s career is usually related to the placement of the team in competitions. This naturally reflects the actual playing performances of both players and teams. Nevertheless, available sources failed to contain an expression of a direct relation between the length of playing career and individual indexes of playing performance. We believe that a reliable evaluation of this relation might complement a rather more objective basis to empirical experience which is precisely what our research endeavoured to find out. We set the following aims:

1. To find what was the make-up of the teams as for the career length of individual players in European Championships in 2000- 2010.
2. To find the influence of the team make-up as for career length on the selected factors of team playing performance.
3. To find out to what extent the make-up of a team as for career length influences the final placement in European Championships.

Methods

Characteristics of the investigated group

In the first part of our research, the investigated sample consists of all the participants of European Women´s Championships (further on just ECHs) in 2000 – 2010. The group comprises 919 players who took part in any ECH during the investigated period. The investigated period remains the same in the second part, but we only deal with 7 teams. These are the teams which took part in all the ECHs in 2000 – 2010. They are the teams of Norway, Denmark, Germany, France, Ukraine, Russia and Hungary. Altogether 434 players were listed in all the teams in the given period, which is about half of all the participants. Besides the number of participations in ECHs, we also investigated the data concerning playing performance.

Methods of evaluation

We drew our data from official information available on the web sites of EHF (http://activities.eurohandball.com/analyses). To evaluate „playing experience" we chose the criterion of the number of participations in ECHs during the followed period (the research started in the year 2000, so the initial data are the same for all the teams, as we did not take in consideration the starts at previous ECHs). The participants were divided into three groups:

A – players who participated in one or two Championships during the investigated period („inexperienced")

B – players who participated in three or four Championships during the investigated period („experienced")

C – players with five or more participations („very experienced")

In the teams which participated in ale the investigated ECHs we allotted one point for each participation to individual players. The sum of points of each team was then put in relation with cumulative indexes of several factors of playing performance in an actual ECH. These included: shooting efficiency, number of assists, number of stolen balls and turn overs, number of blocked shots, goalkeepers´ efficiency. And besides we related the number of points "for participation" with the final placement in a ECH. To evaluate mutual relations, we selected Pearson´s correlation coefficient.

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

The value of the correlation coefficient can oscillate between -1 and 1. The closer to the extreme values, the stronger the dependence. Positive values of the correlation coefficient show a positive dependence (more playing experience means a higher value of the coefficient). Negative values of the correlation coefficient mean a negative dependence. When evaluating the dependence, we applied the value of correlation coefficient higher than ±0.7 as a measure of material significance.

Results

Team make-up

23 national teams took part in ECHs during the investigated period. The participants made various use of including the allowed number of players on the lists and their changes. The investigated group thus consisted of 918 players. By means of a more detailed analysis we found out the following percentages of individual groups:

Group A – 83.79% players
Group B – 14.80% players
Group C - 1.41% players

There is naturally an explanation that a more extensive change of players is understandable, namely if there was a considerable time gap between the participation of a team in ECHs. However, even in teams with regular participation in ECHs (n=7, i.e. nearly 1/3 of all the participants) we have not found extremely different percentages:

Group A – 77.45%
Group B – 20.16%
Group C - 2.39%

Anyway, even in the teams which participated in ECHs regularly, the rate of „experienced“ players does not exceed one quarter of the participants, which might be, among other factors, a consequence of gradual changes of players in the team. We should not forget to mention that there was a large ratio of goalkeepers in C group, out of 13 players with five or more participations five were goalkeepers! Thus it generally seems that coaches do not really bank on the amount of experience (with the exception of goalkeepers) that follows from the length of the career, but rather on the current form of a player or her ability to adapt to dynamic development of handball.

As has been stated above, the relationships between individual factors of playing performance and the make-up of a team were investigated only in the teams that took part in all the ECHs in the given period. See Table 1 for the number of points that express playing experience.

	NOR	DEN	FRA	GER	HUN	RUS	UKR
2000	16	16	16	16	16	16	16
2002	22	22	25	21	24	21	21
2004	27	25	27	27	28	25	23
2006	35	23	36	30	33	32	31
2008	34	31	29	36	31	30	27
2010	45	37	38	40	40	33	30

Tab.1 Summary expression of the evaluation of player’s participation in ECHs in points.

The above mentioned results suggest a relatively stable make-up of the NOR team (a higher number of points means a higher number of repeated participations), on the other hand there is a tendency to rather extensive changes apparent in the team of UKR.

Both individual and team playing performance can be described and evaluated by means of a number of factors. The following were selected for the purposes of our research: shot efficiency, number of assists, number of stolen balls and turn overs, number of blocked shots, goalkeepers´ efficiency.

Shot efficiency and thus also goalkeepers´ efficiency tends to be generally regarded as one of the most important factors of playing performance, whereas other factors are often connected to anticipation. Therefore we believe that „playing experience“ might often be manifested in these factors.

Shot efficiency

The results of the investigation of shot efficiency to the length of playing career are very interesting. A positive (but not high) correlation was found only in three teams (NOR, RUS, UKR). The remaining teams had a negative correlation. It is even materially significant (t = -0.725) in the team of HUN. A negative correlation means that the more experienced the player, the less probable a lower shot efficiency. We can perhaps speculate that a more frequent participation in ECHs enables the opponent teams to get to know a certain player and prepare the goalkeepers better for her. Nevertheless, the relation may apply also vice versa – a multiple participation in ECHs means a better knowledge of the opponent´s goalkeepers (compare the number of repeated participations as for goalkeepers) and consequently better information for targeting the shots. Yet another explanation implies that with increasing age it gets more difficult to achieve a high level of dynamic strength level necessary namely for shots from the area of backs. See Table 2 for a detailed survey of the relationship of shot efficiency and the length of playing career.

Number of assists

Similar results have been found in the relation of the length of active career and the number of assists. A positive value of the correlation has been discovered only in two teams (RUS, NOR). In other teams it is therefore valid that the higher number of participations in ECHs means a lower number of assists. We can again speculate that it might be the consequence of more knowledge and information and that the opponent teams were able to better prepare for cooperation during the offensive phase of individual teams. On the other hand it is possible to consider the fact that even slight changes in the make-up of the team complicate (do not enable) the realization of well-trained combinations (cooperation during offensive phase of game). It should also be added that the assessment of assists is one of the hardest tasks for the observers collecting data for statistical evaluation. Various perception of the course of the game situation might thus partly influence objectivity of the data. See Table 2 for a detailed survey of the relationship of number of assists and the length of active career.

Turn overs

The notion of a positive influence of the length of career on playing performance is best fulfilled by the correlation between the number of turn overs and career length. There is a negative correlation coefficient found in all the teams. In other words – the longer the playing experience, the lower number of turn overs. This relationship even has material significance in the teams of HUN and UKR! It might be speculated that more frequent changes in the make-up of a team result in a less coordinated game and therefore in a higher number of misunderstandings and the following higher number of turn overs. Nevertheless, the least closeness of the relationship was found in the teams of FRA and GER, which are among those in which the change of the team make-up during the investigated period was not as significant as for instance in the teams of UKR and DEN (see Table 1) This suggests that individual experience of individual players will probably carry more weight. Statistical data are presented in Table 2.

Goalkeepers´ efficiency

When evaluating the playing performance, it is necessary to maintain a certain balance in the assessment of indexes of the play in offensive and defensive phases. That is partly why we selected three factors documenting playing in defence. Many coaches consider goalkeepers´ efficiency to be the most complex index of defensive play, as it reflects (namely on top level) not just the actual performance of the goalkeeper, but the team effectivity of players in the field during the defensive phase. A strong tendency of higher effectivity connected with growing experience of the players has been confirmed in a number of investigated teams. It should be noticed in this connection that four out of the investigated teams (NOR, DEN, HUN and GER) have their goalkeepers in group C. And just as it is in shots, there are two exceptions as well. The reams of DEN and UKR have a negative correlation coefficient, which is namely interesting in DEN team. This relation is even materially significant in UKR team! As it is the team with the most change in the team make-up (of all the investigated teams), we might speculate that the cause might be rather the performance of the whole team in the defensive phase. Data see Table 2.

Number of blocked shots

Goalkeepers´ efficiency is closely related to the number of shots blocked by defenders. The system of defence applied by the team naturally plays an important role as well. Blocking is usually connected with the systems with a low number of forward defenders (namely with the system 6:0). But blocking, even in open defensive systems, can be applied either as an „emergency“ solution of a current playing situation or in standard playing situations (free throw). Neither in this factor was there found an unequivocal influence of playing experience. Therefore we were rather surprised that in the teams with the dominant playing system 6:0 (DEN, NOR) we have found out a negative correlation coefficient, meaning a tendency of a decreasing number of blocked shots with increasing playing experience. The bases for explanation might be found in a deeper analysis of the conception of play in defence, which unfortunately exceeds the given range of our contribution. See Table 2 for a detailed survey of the relationship of number of blocked shots and the length of playing career.

Stolen balls

In the defensive phase, the notion of a positive influence of career length on playing performance is best fulfilled by the connection between the number of stolen balls and career length. Anticipation plays the main role in steals. The ability to „read“ the opponent´s game depends, among other factors, also on the amount of experience of individual players and thus on the length of their active careers. Its influence is confirmed by the fact that with the exception of UKR, this dependence is materially significant in all the teams. Statistical data are presented in Table 2.

Placement

All the above mentioned factors influence the playing performance of a team and thus also the final placement in ECHs. Therefore we also correlated overall placement of a team and the length of active playing career. It follows from the results presented in Table 2 that materially significant connection between placement and career length has been found only in one team (HUN). In this case a higher playing experience means a „higher“ (worse) placement. There might be an explanation that a higher number of participations means that the opponents have detailed information concerning the way of play at their disposal, thus being able to prepare better for matches. The alternative that with view to a higher age of the players there is a decrease in condition predispositions cannot be judged without the knowledge of respective data, so we are not dealing with it any further.

	TS EFF	AS	TO	GK EFF	BS	ST	PL
NOR	0.509	0.021	- 0.891	0.867	- 0.532	0.940	- 0.678
DEN	- 0.515	- 0.109	- 0.670	- 0.251	- 0.671	0.808	0.111
FRA	- 0.134	- 0.333	- 0.439	0.910	0.205	0.850	- 0.349
GER	- 0.131	- 0.129	- 0.401	0.851	0.217	0.818	0.081
HUN	- 0.725	- 0.578	- 0.823	0.670	0.232	0.888	0.751
RUS	0.181	0.406	- 0.571	0.646	0.444	0.709	0.132
UKR	0.267	- 0.541	- 0.837	- 0.704	- 0.059	0.397	0.491

Tab. Nr. 2. Overview of correlation coefficients (TS EFF – team shots efficiency, AS – assists, TO – turnovers, GK EFF – goalkeepers efficiency, BS – blocked shots, ST – steals, PL – placement)

Discussion and conclusions

Make-up of teams

The percentage of the three groups defined by us suggests that players most frequently appear in one or two Championships. Hypothetically, the most usual composition of an EC team (consisting of 16 players) could be calculated like this: 12 players from A group, 3 players from B group and maximally one player from C group. From this point of view it seems that when nominating players, coaches prefer rather current sports form or other factors, whereas playing experience is not a necessary prerequisite of participation. However, it should be emphasized that the source of playing experience is not only participation at ECHs, but also at World Championships, or Cup competitions, or else Olympic Games. During the period we investigated there were five World Championships and three Olympic Games. The number of participations of the investigated teams oscillates between eight (FRA, HUN) and four (GER). There should be also added the participation of most players in club cups. Especially in their finals, they are mostly matches with playing performance on the level of top representative events. In other words – even players included in A group can, during a relatively short time, get sufficient experience necessary for the participation in an ECH.

Playing performance

The efficiency of individual playing activities is generally influenced by a number of factors like technique, tactics, level of fitness, current mental state etc. The length of active career may play here both a positive role (perfection of technique, tactical experience, mental resilience) and a negative one (deficits as for condition, social relationships). With regard to different personal characteristics of individual players the impact of experience is different even in within the range of individual teams. That is why we found a different relationship between their number, or efficiency, and the length of playing career in most of the selected playing activities. The results confirm the empirical finding that playing experience has the most impact on playing activities in which anticipation plays a major part. From this point of view it is interesting that there has been found a higher material significance in a defensive activity - stolen balls, than in an offensive activity – turn overs.

We might speculate that in offensive, a player is more limited by the rules concerning playing the ball, and thus certain individual flaws for example in technique or preparedness of current condition can be more difficult to eliminate by mere anticipation. Even with view to the more numerous representation of goalkeepers in C group we may have expected a higher material dependence between their efficiency and the length of playing career. This was only manifested in the teams of FRA, NOR and GER. Here it should be mentioned that goalkeepers are not really a numerous group, which may influence the calculation of their efficiency. There is a hint of a tendency in the comparison of the relationship of the length of an active playing career and offensive and defensive activities. There was only one team (UKR) which showed prevalence of a negative influence of playing experience on defensive activities. At the same time, it is a team with the worst total placement. In four teams (DEN, FRA, GER and HUN), there is a prevalence of negative impact on offensive activities, in DEN team there is a „balanced“ influence

Placement

The final placement of a team in a competition may be influenced by a number of circumstances as well. These factors may be manifested either directly (playing system) or in the playing efficiency (injuries of players). The preceding text clearly suggests that playing experience may be included in the second group as well. If its impact on playing performance is not unambiguous, it cannot be ambiguous even with respect to placement. That is why a materially significant dependence has been found in one team only. However, when analyzing the results in greater detail, we find out that the two teams with the lowest sum of placements during the investigated period (NOR, RUS) also have the lowest number (1, 0 respectively) of factors of playing performance negatively influenced by the length of playing career!

Conclusions

- playing experience expressed by the number of participations in ECHs is neither the sole or main factor deciding about the personal make-up of a team, as coaches rather prefer current sports form or other factors
- the influence of playing experience on individual factors of playing performance is not unambiguous. A more significant positive influence has been documented in the playing activities with a high impact of anticipation
- the length of playing career has a negative influence rather on offensive factors of playing performance
- the teams that are able to eliminate the negative influence of the length of active career on individual factors of playing performance have a hope of a better placement

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THE EFFECT OF MORPHOLOGICAL PARAMETERS ON PLAYER PERFORMANCE IN ELITE FEMALE HANDBALL GOALKEEPERS

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SUMMARY
The purpose of the cross-sectional study was to determine the effect of morphological parameters on player performance in elite female handball goalkeepers. The correlation analysis showed that investigated morphological parameters in both U17 and U19 goalkeepers poorly correlated with goalkeeping efficiency assessed using 6 cumulative goalkeeping statistics.

Keywords
Anthropometry, competitive performance, handball players

Introduction
The performance of goalkeepers has a fundamental effect upon the performance of the team. Goalkeepers' performances are multifactorial manifestations of abilities and skills, where individual factors co-interact. Top level goalkeepers are supple and fast. Somatically, goalkeepers have long arms and are mostly tall. (Kovacs, 2009). Previous studies dealing with handball goalkeepers have investigated their psychological traits (Kajtna et al., 2012), associations between motor abilities and competitive performance (Pori et al., 2012) or cumulative statistics of goalkeeping efficiency (Táborský, 2008, Rizescu, Mihaila, Macovei, 2009). However, there is a paucity of studies dealing with the association between morphological parameters and goalkeeping efficiency. Only few studies have dealt with the effect of anthropometric parameters on goalkeeper's performance (Visnapuu et al., 2011).

Methods
The purpose of the cross-sectional study was to determine the effect of morphological parameters on player performance in elite female handball goalkeepers.

One hundred eighty-five elite female players participated in the study. In total, the study sample consisted of forty-two U17 goalkeepers and thirty-five U19 goalkeepers. All goalkeepers were tested during 2011 Women's 17 and Women's 19 European Handball Championships in Czech Republic and Netherlands, respectively. The goalkeepers were divided into four performance groups according to the final team standings: 1st to 4th place (1-4), 5th to 8th place (5-8), 9th to 12th place (9-12) and 13th to 16th place (13-16). The following morphological parameters were measured and correlated with goalkeeping efficiency: body height, body mass, percentage subcutaneous fat (fat %), arm span (D-D), shoulder breadth (A-A) and somatotype components: endomorphy, mesomorphy and ectomorphy. The somatotypes were determined according to Heath, Carter (1967). Goalkeeping efficiency was assessed using six EHF cumulative statistics based on the following parameters: total goal save percentage, goal saves from 7 meters, goal saves from 9 meters, goal saves from 6 meters, saves from wing positions and saves following a fast break. The effect of morphological parameters on goalkeeping efficiency in goalkeepers was determined using Spearman's rank order correlation.

Results and discussion

The data were analyzed in terms of goalkeepers' morphological parameters, goalkeeping efficiency and correlation between goalkeeping efficiency and morphological parameters. Mean values of morphological parameters and 6 goalkeeping efficiency statistics are presented in Tables 1 through 8. The correlation coefficients expressing associations between morphological parameters and variables of goalkeeping efficiency are presented in Table 5.

As shown in Table 1, mean values of morphological parameters in U17 goalkeepers: body height, arm span, shoulder breadth are highest in 1-4 performance group. This has shown that goalkeepers of 1-4 group are taller with greater arm span and skeletal robustness. The difference between mean body height and mean arm span was negative in 13-16 group only. The highest mean value of body mass was observed in 13-16 group of goalkeepers. An interesting finding is higher percentage of subcutaneous fat found in 9-12 and 13-16 groups compared to 1-4 and 5-8 groups. This is indicative of lower volume of fat-free mass. As for the somatotype components, the lowest degree of relative fatness as expressed by endomorphy was found in 5-8 goalkeepers. All groups were predominantly mesomorphic. Somatotype categories were found to be identical in groups 9-12 and 13-16, but different in 1-4 and 5-8 groups. Mean somatotypes in groups 9-12 and 13-16 were categorized as *endomorphic mesomorphs*. Mean somatotype in 1-4 group was classified as *balanced mesomorph* and in 5-8 group as *ectomorphic mesomorph*.

Tab. 1 *Morphological parameters: U17 goalkeepers*

Ranking	**1st - 4th**	**5th - 8th**	**9th - 12th**	**13th - 16th**
	X ±SD	*X ±SD*	*X ±SD*	*X ±SD*
Body Height (cm)	180.1±3.77	177.3±3.37	176.1±4.71	175.6±6.14
D-D (cm)	181.6±5.77	178.7±2.53	177.8±5.70	174.7±6.41
A-A (cm)	39.8±1.80	38.4±1.16	39.5±1.64	38.6±1.66
Body Mass (kg)	74.5±4.54	69.1±5.06	72.5±5.09	74.6±8.06
Fat (%)	11.7±2.46	9.1±3.94	14.1±2.58	14.0±5.89
Endomorphy	2.3±0.37	1.8±0.93	2.8±0.61	3.0±1.22
Mesomorphy	3.8±0.57	3.3±0.93	3.9±0.57	4.4±1.35
Ectomorphy	2.6±0.47	2.8±0.74	2.1±0.73	2.0±1.16

Tab. 2 *Morphological parameters: U19 goalkeepers*

Ranking	**1st - 4th**	**5th - 8th**	**9th - 12th**	**13th - 16th**
	X ±SD	*X ±SD*	*X ±SD*	*X ±SD*
Body Height (cm)	176.1±4.70	176.3±4.39	178.3±4.99	176.9±2.91
D-D (cm)	175.7±4.53	180.4±3.03	177.9±5.18	174.8±5.14
A-A (cm)	40.3±0.71	39.5±2.19	38.6±1.29	38.5±1.27
Body Mass (kg)	73.5±4.51	79.3±11.15	73.0±6.75	73.3±6.03
Fat (%)	14.20±2.69	13.8±6.36	12.2±3.65	13.0±3.01
Endomorphy	2.7±0.72	3.0±1.51	2.2±0.72	2.5±0.65
Mesomorphy	4.3±1.13	4.7±1.79	3.9±1.60	3.8±0.93
Ectomorphy	2.0±0.81	1.9±0.92	2.5±1.67	2.2±0.81

Unlike U17 goalkeepers, mean body height in U19 goalkeepers was found to be lowest in 1-4 group. Negative difference between body height and arm span was observed in 13-16 group only. The highest degree of skeletal robustness expressed by shoulder breadth was found in 1-4 group. Mean body mass was greatest in 5-8 group. The differences between mean values of body mass in 1-4, 9-12 and 13-16 groups were minimal. Paradoxically, the highest volume of subcutaneous fat was observed in 1-4 group. However, the highest volume of subcutaneous fat in kilograms was found in 5-8 group. Mean values of endomorphic components ranged from 2.2 to 3.0. The highest degree of relative fatness expressed by endomorphy was observed in 5-8 group. Mean somatotypes of all groups were found to be predominantly mesomorphic. The highest degree of muscular development was observed in 5-8 group. Mean somatotypes in groups 1-4 and 5-8 were identically categorized as *endomorphic mesomorphs*. The same was observed in groups 9-12 and 13-16 as mean somatotypes in both groups were identically classified as *balanced mesomorphs.*

Tab. 3 *Goalkeeping efficiency: U17 goalkeepers*

Ranking	**1st - 4th**	**5th - 8th**	**9th - 12th**	**13th - 16th**
	Total ±SD	*Total ±SD*	*Total ±SD*	*Total ±SD*
Total shots	809±74.81	1109±34.36	1150±67.14	1174±70.65
Total saves	310±30.63	376±11.59	387±25.77	388±26.25
Total % saves	**38.3**	**33.9**	**33.7**	**33.0**
6m shots	211±21.39	296±12.93	290±16.69	291±20.89
6m saves	77±7.09	111±5.62	92±5.21	97±6.98
6m % saves	**36.5**	**37.5**	**31.7**	**33.3**
7m shots	72±6.58	133±6.57	81±5.31	96±3.89
7m saves	10±1.71	30±2.00	17±1.30	27±1.83
7m % saves	**13.9**	**22.6**	**21.0**	**28.1**
9m shots	225±20.89	224±10.03	302±21.53	232±10.67
9m save	108±11.52	112±4.65	156±13.43	109±6.13
9m % saves	**48.0**	**50.0**	**51.7**	**47.0**
Wing shots	125±12.34	162±5.17	185±9.28	164±9.48
Wing saves	64±7.60	64±2.59	78±5.14	72±5.30
Wing % saves	**51.2**	**39.5**	**42.2**	**43.9**
FB shots	115±13.23	187±7.97	197±14.44	239±14.49
FB saves	43±5.72	40±1.67	34±2.71	49±4.60
FB % saves	**37.4**	**21.4**	**17.3**	**20.5**

As shown in Table 3, the total percentage of saves was highest in group 1-4 and lowest in 13-16 group. The table clearly shows that the number of shots at the goal was lowest in 1-4 group. This is indicative of good defense strategy of the team and individual defensive skills of players. However, goalkeeping efficiency when saving shots from 6-meter distance was highest in 5-8 group. When standing against 7-meter shots, the highest number of saves was paradoxically observed in 13-16 group. Table 1 shows that goalkeepers in 9-12 group had to save the highest number of shots from 9-meter distance and were also most effective in saving them reaching over 50 percent efficiency. However, the highest degree of goalkeeping efficiency from the wing positions and after fast breaks was found in group 1-4.

As compared to the U17 category, the total number of shots at the goal was lower in U19 category than in U17 category. The highest goalkeeping efficiency was observed in 9-12 group as evidenced by the lowest total number of shots at the goal and highest percentage of saves. However, the goalkeepers in 1-4 group were most effective when saving shots from 6-meter distance. The lowest number of shots at the goal was again found in 5-8 group. Similarly to the saves from 6 meters, the goalkeepers in group 1-4 were most effective when standing against 7-meter throws and 9-meter shots. An interesting finding is that the lowest number of shots from wing positions and the highest goalkeeping efficiency was observed in group 9-12. The highest number of shots at the goal after fast breaks was observed in 13-16 group, which demonstrated second best goalkeeping efficiency when saving shots after fast breaks. Goalkeepers on teams in 5th to 8th place were most effective in terms of covering shots after fast breaks.

Tab. 4 *Goalkeeping efficiency: U19 goalkeepers*

Ranking	**1st - 4th**	**5th - 8th**	**9th - 12th**	**13th - 16th**
	Total ±SD	*Total ±SD*	*Total ±SD*	*Total ±SD*
Total shots	861±73.00	819±59.90	772±73.85	1089±49.47
Total saves	299±26.27	257±21.41	277±30.16	359±22.48
Total % saves	**34.7**	**31.4**	**35.9**	**33.0**
6m shots	233±21.90	233±16.99	175±18.54	250±12.95
6m saves	81±8.49	65±5.78	52±5.85	71±6.11
6m % saves	**34.8**	**27.9**	**29.7**	**28.4**
7m shots	95±7.62	103±8.07	89±8.39	119±4.78
7m saves	20±2.12	19±2.29	16±2.69	19±1.29
7m % saves	**21.1**	**18.4**	**18.0**	**16.0**
9m shots	290±25.39	241±19.84	301±28.39	367±20.91
9m saves	138±13.28	100±9.58	141±14.41	172±11.64
9m % saves	**47.6**	**41.5**	**46.8**	**46.9**
Wing shots	105±13.43	89±9.68	107±12.32	166±8.37
Wing saves	37±4.00	39±4.08	55±7.11	61±4.52
Wing % saves	**35.2**	**43.8**	**51.4**	**36.7**
FB shots	95±16.60	91±7.61	72±6.69	142±6.49
FB saves	15±1.90	21±2.12	9±1.62	25±1.71
FB % saves	**15.8**	**23.1**	**12.5**	**17.6**

As shown in Table 5, the Spearman’s rank order correlation did not reveal associations between morphological parameters and goalkeeping variables in both age categories. The only statistically significant positive correlation was observed between body mass and percentage of saves when covering shots from wing positions. Our findings are consistent with the results reported by Visnapuu et al. (2011) who found that body mass correlated with 6-meter shots saved. Overall, it may be concluded that morphological parameters are poor predictors of goalkeeping efficiency in young female handball goalkeepers as evidenced by correlates presented in Table 5.

Tab. 5 *Correlation between morphological parameters and goalkeeping efficiency*

	Ech Women 17						*ECh Women 19*					
	Total	**7m**	**9m**	**6m**	**Wing**	**FB**	**Total**	**7m**	**9m**	**6m**	**Wing**	**FB**
BH	-0.13	-0.13	-0.15	0.08	-0.03	0.01	0.14	0.15	0.04	-0.08	0.15	0.25
D-D	0.06	-0.17	-0.03	0.06	0.15	0.16	0.09	0.14	-0.07	0.1	0.2	0.29
A-A	-0.07	-0.19	0.08	-0.01	0.007	0.06	-0.14	0.02	-0.1	0.09	-0.24	-0.17
BM	0.12	0.03	0.21	0.02	-0.07	-0.05	0.16	0.16	-0.03	0.2	**0.38**	0.09
Fat%	-0.04	0.16	-0.02	-0.04	-0.12	-0.15	0.24	-0.09	0.13	0.43	0.25	0.03
Endo	-0.03	0.19	-0.06	-0.07	-0.15	-0.21	0.14	-0.02	0.004	0.31	0.24	-0.1
Meso	0.16	0.14	0.06	0.13	0.03	0.01	-0.007	-0.08	-0.02	0.17	0.08	-0.11
Ecto	-0.1	-0.17	0.03	0.04	-0.04	0.02	0.07	0.05	0.09	-0.13	-0.11	0.07

BH - body height, **BM** - body mass, **Fat %** - fat percentage, **Endo** - endomorphy, **Meso** - mesomorphy, **Ecto** - ectomorphy, **FB** - fast break

Conclusions

The results of the study showed that U17 female goalkeepers in 1-4 group were taller and heavier compared to the remaining groups of goalkeepers. In both age groups goalkeepers on 1-4 teams were found to have more percent subcutaneous fat than their age-matched counterparts in groups 5-8, 9-12 and 13-16.

In U17 goalkeepers, the total percentage of saves was highest in group 1-4 confirmed by the lowest number of shots at the goal as well. Furthermore, the highest degree of goalkeeping efficiency from the wing positions and after fast breaks was also found in group 1-4.

Total number of shots at the goal was lower in U19 category than in U17 category. The highest goalkeeping efficiency was observed in 9-12 group as evidenced by the lowest total number of shots at the goal and highest percentage of saves. The goalkeepers in 1-4 group were most effective when saving shots from 6-, 7-, and 9-meter distances. The lowest number of shots from wing positions and the highest goalkeeping efficiency was observed in group 9-12. As for covering shots following fast breaks goalkeepers on teams in 5^{th} to 8^{th} place were found to be most effective.

Mean somatotypes in the 1-4 and 5-8 groups of U19 goalkeepers were categorized as endomorphic mesomorphs. However, the same somatotype categorization was observed in U17 goalkeepers in 9-12 and 13-16 groups. Overall, three somatotypes categories in both U17 and U19 goalkeepers were observed: endomorphic mesomorph (4 groups), balanced mesomorph (3 groups) and ectomorphic mesomorph (1 group).

Correlation analysis did not reveal associations between morphological parameters and goalkeeping variables in both age categories. It may be concluded that morphological parameters poorly correlate with competitive performance of young female handball goalkeepers.

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THE RELATIONSHIP BETWEEN MORPHOLOGICAL PROFILE AND PLAYER PERFORMANCE IN ELITE FEMALE HANDBALL PLAYERS

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Summary
The purpose of this cross-sectional study was to determine the relationship between morphological profile and player performance in elite female handball players. The results showed that with respect to playing function, overall shooting efficiency in the teams that placed in 1st to 4th place as compared to their counterparts in 13th to 16th was higher in all playing positions except backs and the morphological profile in players on the 1st to 4th teams was more favorable.

Keywords
Team sports, anthropometric variables, somatotype, shooting efficiency

Introduction
The modification of team handball rules changed the character of the game. However, final game score determined by both individual player performances and team performances has remained the most important game statistic. The final score depends on a variety of factors present in both defensive and offensive phase of the game. Shooting as an individual game skill and as a completion of the attacks is regarded as a highly relevant factor. Shooting efficiency is directly dependent on the proficiency of shot execution, technique, tactics and creativeness of players. In addition to shooting skills, players also benefit from an appropriate morphological structure (Srhoj, Marinović, Rogulj, 2002, Acsinte, Alexandru, 2007, Mohamed et al., 2009, Šibila, Pori, 2009, Urban, Kandráč, Táborský, 2010).

Methods
The purpose of the cross-sectional study was to determine the relationship between morphological profile and player performance in elite female handball players.

One hundred eighty-five elite female players volunteered to participate in the study. The study sample consisted of 56 wing players, 39 center backs, 56 backs and 34 pivots. All players were tested during 2011 Women's 17 and Women's 19 European Handball Championships in Czech Republic and in Netherlands, respectively. The players were assigned to two groups according to the final team standings: 1st to 4th place and 13th to 16th place. The following anthropometric parameters were measured and correlated with shooting efficiency: body height, body mass, percentage subcutaneous fat, arm span, shoulder breadth and three somatotype components. The somatotypes were determined according to Heath, Carter (1967). Shooting efficiency of players was evaluated using four EHF cumulative statistics based on goal percentages. Shooting efficiency was assessed in terms of total goal percentage, goal percentage from 6-meter range, goal percentage from 9 meter range and goal percentage following a fast break. The relationship between selected morphological parameters and total goal percentage in players was determined using Spearman's rank order correlation.

Results and discussion

The data were analyzed with respect to players' morphological parameters, shooting efficiency and association between shooting efficiency and morphological parameters. Mean values of morphological parameters and 4 shooting efficiency statistics are presented in Tables 1 through 8.

In U17 category, mean values of all morphological parameters in 1st to 4th teams were higher compared to mean values of the 13th to 16th teams. As shown in Table 1, wing players on the teams in 1st to 4th place may be characterized as taller and heavier with higher percentage subcutaneous fat. As for somatotype components of W19 wing players, the greatest differences were observed in relative fatness and muscularity expressed by endomorphy and mesomorphy, respectively. The mean somatotypes of top teams were categorized identically as *balanced mesomorphs*. The difference between somatotype categories was found in U19 category as mean somatotype in top teams was classified as *balanced mesomorph*, while mean somatotype of 13th to 16th teams was categorized as *ectomorphic mesomorph*.

Tab. 1 *Morphological parameters - Wing players*

Category	***ECh Women 17***		***ECh Women 19***	
Ranking	**1st - 4th**	**13th - 16th**	**1st - 4th**	**13th - 16th**
	X ±SD	*X ±SD*	*X ±SD*	*X ±SD*
Body Height (cm)	169.4±4.58	166.4±5.15	171.4±6.03	170.7±3.93
D-D (cm)	167.6±6.08	165.9±6.51	169.1±8.24	170.8±5.20
A-A (cm)	37.9±1.09	37.7±1.52	38.5±1.44	38.4±1.23
Body Mass (kg)	63.9±6.27	60.5±4.01	68.1±5.31	62.4±5.61
Fat (%)	9.6±3.39	9.5±3.75	11.9±3.25	7.8±3.75
Endomorphy	2.0±0.71	2.0±0.68	2.3±0.74	1.5±0.72
Mesomorphy	4.3±0.89	4.1±0.98	4.5±1.00	3.6±0.87
Ectomorphy	2.2±0.65	2.2±0.99	2.0±0.84	2.8±0.82

Tab. 2 *Shooting efficiency - Wing players*

Category	***ECh Women 17***		***ECh Women 19***	
Ranking	**1st - 4th**	**13th - 16th**	**1st - 4th**	**13th - 16th**
	Total ±SD	*Total ±SD*	*Total ±SD*	*Total ±SD*
Total shots	242±11.30	268±9.84	344±17.76	317±11.72
Total goals	148±8.44	142±6.84	193±10.96	162±7.21
Total % goals	**61.2**	**53.0**	**56.1**	**51.1**
6m shots	19±1.08	31±1.77	83±7.93	60±4.21
6m goals	15±0.66	13±0.81	41±4.29	23±1.45
6m % goals	**78.9**	**41.9**	**49.4**	**38.3**
Wing shots	110±6.56	131±5.51	148±11.91	160±9.13
Wing goals	53±3.97	61±3.79	77±6.55	77±4.81
Wing % goals	**48.2**	**46.6**	**52.0**	**48.1**
FB shots	74±3.24	75±3.14	70±4.55	67±3.90
FB goals	55±3.12	48±2.20	51±3.47	52±2.94
FB % goals	**74.3**	**64.0**	**72.9**	**77.6**

In W17 group, the total goal percentage was highest in 1st to 4th teams. Shooting efficiency was higher in top teams than in teams at the bottom of the final standings. The greatest difference in shooting efficiency between teams was found in shooting from 6-meter range. However, the lowest difference in shooting efficiency was observed when shooting from the wing positions. What should be noted is higher number of goals following fast breaks in U19 group.

Tab. 3 *Morphological parameters - Center backs*

Category	*ECh Women 17*		*ECh Women 19*	
Ranking	**1st - 4th**	**13th - 16th**	**1st - 4th**	**13th - 16th**
	X ±SD	*X ±SD*	*X ±SD*	*X ±SD*
Body Height (cm)	174.3±2.91	171.5±5.31	172.9±2.42	174.5±5.69
D-D (cm)	174.5±3.05	170.5±5.19	172.4±4.59	173.7±6.47
A-A (cm)	39.5±0.78	38.2±1.23	39.3±1.68	38.5±1.44
Body Mass (kg)	67.8±5.35	66.0±6.07	69.6±5.82	66.2±5.55
Fat (%)	10.9±3.24	11.4±4.57	13.2±3.60	9.1±3.13
Endomorphy	2.4±0.62	2.4±0.95	2.5±0.70	1.8±0.49
Mesomorphy	3.9±0.62	3.8±0.67	4.3±0.73	3.3±0.94
Ectomorphy	2.5±0.48	2.3±0.76	2.0±0.67	2.8±0.78

As shown in Table 3, the comparison of mean values between 1st to 4th teams and 13th to 16th teams revealed differences in all morphological parameters except somatotype categories. Overall, players of top teams of U17 category may be characterized as taller, heavier with greater shoulder breadth and lower percentage fat. The somatotype categories in both U17 groups were identical: balanced mesomorphs. In U19 category, center backs on teams in 1st to 4th position were shorter and heavier compared to their 13th to 16th team counterparts. The difference between groups was found in somatotype categories as top players' (1st to 4th place) were found to be *balanced mesomorphs*, whereas mean somatotype in players in 13th to 16th place was categorized as *ectomorphic mesomorph.*

Tab. 4 *Shooting efficiency - Center backs*

Category	*ECh Women 17*		*ECh Women 19*	
Ranking	**1st - 4th**	**13th - 16th**	**1st - 4th**	**13th - 16th**
	Total ±SD	*Total ±SD*	*Total ±SD*	*Total ±SD*
Total shots	305±20.37	248±13.26	209±25.87	350±32.73
Total goals	179±11.52	111±6.42	112±13.73	177±17.96
Total % goals	**58.7**	**44.8**	**53.6**	**50.6**
6m shots	59±3.95	70±5.07	59±7.09	55±4.69
6m goals	34±2.82	34±2.57	34±3.53	28±2.61
6m % goals	**57.6**	**48.6**	**57.6**	**50.9**
9m shots	134±11.37	83±6.72	90±11.65	154±15.00
9m goals	51±4.03	21±2.31	34±4.84	54±6.73
9m % goals	**38.1**	**25.3**	**37.8**	**35.1**
FB shots	35±3.25	46±4.57	8±0.71	15±2.06
FB goals	30±3.23	31±2.25	8±0.71	9±3.14
FB % goals	**85.7**	**67.4**	**100**	**60.0**

In U17 category, total goal percentage was higher in top teams by 12.9 percent. All four goal percentage statistics favor the top teams. The greatest difference in shooting efficiency was observed when shooting following a fast break. The same differences in goal percentages between team groups were found in U19 category. Even the greatest difference in shooting efficiency equaling 40 percent was identically found when shooting after a fast break.

Tab. 5 *Morphological parameters - Backs*

Category	***ECh Women 17***		***ECh Women 19***	
Ranking	**1st - 4th**	**13th - 16th**	**1st - 4th**	**13th - 16th**
	X ±SD	*X ±SD*	*X ±SD*	*X ±SD*
Body Height (cm)	179.8±4.38	176.1±5.79	178.1±4.39	180.1±5.45
D-D (cm)	180.6±3.72	176.2±5.68	179.5±3.49	181.1±5.23
A-A (cm)	39.5±1.70	39.2±1.46	40.0±0.75	40.5±1.04
Body Mass (kg)	71.4±3.43	70.9±6.74	72.8±5.12	75.0±4.70
Fat (%)	10.2±2.16	12.1±4.21	10.2±2.93	11.0±2.35
Endomorphy	2.2±0.49	2.5±0.82	1.9±0.56	2.2±0.60
Mesomorphy	3.6±1.19	3.9±0.93	4.0±0.73	3.9±1.03
Ectomorphy	2.9±0.75	2.4±0.92	2.3±0.93	2.5±0.91

As shown in Table 5, U17 groups of players differed in all morphological parameters favoring backs in 1st to 4th teams. The backs on top teams may be characterized as taller, heavier with greater arm span and lower percentage fat. As for somatotype categories, both groups were predominantly mesomorphic. The top backs in U17 category were categorized as *ectomorphic mesomorphs*, while backs on 13th to 16th teams were categorized as *balanced mesomorphs.* Mean somatotypes in U19 category were identical and were both classified as *balanced mesomorphs.*

Tab. 6 Shooting efficiency - Backs

Category	***ECh Women 17***		***ECh Women 19***	
Ranking	**1st - 4th**	**13th - 16th**	**1st - 4th**	**13th - 16th**
	Total ±SD	*Total ±SD*	*Total ±SD*	*Total ±SD*
Total shots	346±16.70	606±23.43	439±30.87	482±22.11
Total goals	182±8.18	322±13.48	237±18.45	230±12.38
Total % goals	**52.6**	**53.1**	**54.0**	**47.7**
6m shots	45±2.94	141±4.52	83±8.08	55±3.19
6m goals	24±1.80	76±3.15	48±4.86	27±1.82
6m % goals	**53.3**	**53.9**	**57.8**	**49.1**
9m shots	192±10.68	243±13.39	224±15.80	333±16.53
9m goals	85±4.84	90±5.68	99±7.38	135±8.17
9m % goals	**44.3**	**37.0**	**44.2**	**40.5**
FB shots	30±3.61	54±3.42	23±2.72	15±0.96
FB goals	20±2.65	38±2.10	18±2.06	13±0.94
FB % goals	**66.7**	**70.4**	**78.3**	**86.7**

In U17 category, mean goal percentages in 4 shooting efficiency statistics revealed contradictory findings as higher goal percentage was observed in 3 of 4 statistics: total goal percentage, 6-meter goal percentage and goal percentage after a fast break. The greatest difference between teams was found in 9-meter goal percentage. On the contrary, the opposite was observed in U19 category where backs on top teams showed lower efficiency only when shooting after a fast break. The greatest difference favoring backs on top four teams was observed when shooting from 6-meter distance. The comparison of both age categories revealed greater inter-team differences in U19 backs.

Tab. 7 Morphological parameters - Pivots

Category	***ECh Women 17***		***ECh Women 19***	
Ranking	**1st - 4th**	**13th - 16th**	**1st - 4th**	**13th - 16th**
	X ±SD	*X ±SD*	*X ±SD*	*X ±SD*
Body Height (cm)	174.2±4.93	171.4±6.19	174.7±5.19	174.2±3.78
D-D (cm)	177.0±6.52	172.2±7.99	176.4±7.50	174.6±3.81
A-A (cm)	40.2±1.32	38.8±1.80	40.4±1.92	39.5±1.37
Body Mass (kg)	78.1±9.14	72.5±11.90	76.4±8.32	77.0±6.13
Fat (%)	14.1±4.52	14.8±4.44	14.2±2.95	14.3±3.23
Endomorphy	2.9±0.84	3.0±0.94	2.9±0.70	3.0±0.87
Mesomorphy	5.2±1.10	5.0±1.10	4.9±0.75	5.1±0.61
Ectomorphy	1.4±0.74	1.5±0.83	1.5±0.61	1.3±0.51

As shown in Table 7, mean values of morphological parameters in U17 category pivots were higher in 6 of 8 morphological parameters. Pivots of top four teams compared to their counterparts may be characterized as taller, heavier with greater shoulder breadth and lower percent fat. As for somatotype categories, both categories in U17 category were *endomorphic mesomorphs.* In U19 category, the differences between mean values of morphological parameters were minimal. Similarly to U17 category, mean somatotype of pivots in both groups of players was categorized as *endomorphic mesomorph.*

Tab. 8 Shooting efficiency - Pivots

Category	***ECh Women 17***		***ECh Women 19***	
Ranking	**1st - 4th**	**13th - 16th**	**1st - 4th**	**13th - 16th**
	Total ±SD	*Total ±SD*	*Total ±SD*	*Total ±SD*
Total shots	127±11.50	165±8.25	129±13.39	141±11.09
Total goals	91±9.08	104±6.58	94±9.33	86±7.45
Total % goals	**71.7**	**63.0**	**72.9**	**61.0**
6m shots	101±10.44	108±8.34	99±12.23	101±9.94
6m goals	72±7.68	73±6.40	74±8.42	68±6.52
6m % goals	**71.3**	**67.6**	**74.7**	**67.3**
FB shots	19±2.12	29±2.10	20±2.90	11±1.22
FB goals	14±1.92	18±1.63	16±2.37	9±0.94
FB % goals	**73.7**	**62.1**	**80.0**	**81.8**

Shooting efficiency in pivots was assessed using only three statistics. Higher goal percentages in U17 category were found in all three statistics: total goal percentage, 6-meter goal percentage and goal percentage after a fast break. The greatest difference in goal percentage was observed when shooting after a fast break. In U19 category, a surprising finding was found in shooting efficiency after fast breaks favoring teams in 13th to 16th place. The difference between teams' shooting efficiency was profound in total goal percentage, where the difference was 11.9 percent. An interesting finding is that the overall number of shots was higher in teams at the bottom of the final standings.

Overall, correlation analysis showed only small number of significant correlations between morphological parameters and total goal percentage in backs. In U17 wings (1^{st} to 4^{th} place), negative correlation (r = - 0.64) was observed between mesomorphy and total goal percentage. Similarly to U17 wings, negative correlation between mesomorphy and total goal percentage was found in U19 category pivots in both groups. Contradictory findings were observed in the relationship between ectomorphy and shooting efficiency in U17 and U19 pivots (13^{th} to 16^{th} place). Ectomorphy negatively correlated with total goal percentage in U17 pivots on the teams in 13^{th} to 16^{th} place (r = - 0.84), while positive correlation between ectomorphy and total goal percentage was found in U19 pivots (r = 0.86).

Conclusions

The results of the study showed that in U17 category players in all playing positions are heavier and taller unlike the U19 category players. As for somatotype components, different somatotype categories were observed in U17 backs, U19 wings and U19 center backs. Overall, somatotypes of players on the teams in 1^{st} to 4^{th} place and in 13^{th} to 16^{th} place were categorized mostly as balanced mesomorphs, endomorphic mesomorphs or ectomorphic mesomorphs.

Overall, shooting efficiency was found to be higher in top teams compared to teams in last places. Lower shooting efficiency in top teams was observed following fast breaks in U17 backs and U19 pivots, wings and backs.

Most associations between investigated morphological parameters and total goal percentage were found to be statistically insignificant. Negative correlations were found between mesomorphy and shooting efficiency in In U17 wings (1^{st} to 4^{th} place) and in U19 category pivots in both groups. Opposite associations were found between ectomorphy and shooting efficiency in pivot playing position as evidenced by both positive and negative correlates.

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MORPHOLOGICAL CHARACTERISTICS AND MOTOR ABILITIES OF AMATEUR FEMALE HANDBALL, BASKETBALL AND VOLLEYBALL PLAYERS

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Summary
Aims of the study: to investigate the relationship and differences between body composition and motor abilities in amateur female handball, basketball and volleyball players. Subjects and methods: Estonian amateur female players (12 handball, 13 basketball and 14 volleyball players) were studied. Conclusion: According to the study volleyball players had the most suitable morphological characteristics and were in better physical shape for competitive sports.

Keywords
Female, handball, basketball, volleyball, body composition, motor abilities.

Introduction

Identification of a specific body composition that may contribute to success in sports as well as possible differences among athletes in various sports are subjects of high interest for sport scientists and coaches (Carter et al. 2005, Malousaris et al. 2008). Successful competition in sports has been associated with specific body composition and anthropometrical parameters (Bayios et al. 2006). It is well known that height gives an advantage in team sports (van den Tillaar & Ettema 2004, Carter et al. 2005, Granados et al. 2007, Malousaris et al. 2008). Long-term training processes in sports games along with appropriate selection lead to the formation of optimal and specific body composition and motor development which are responsible for achievement of top performance in certain sports (Čavala et al. 2008).

The aims of the present study were:

1. To compare differences in body composition and motor abilities in amateur female handball, basketball and volleyball players.
2. To investigate the relationship between body composition and motor abilities in amateur female handball, basketball and volleyball players

Subjects and methods

In total 39 Estonian amateur female players were studied - 13 basketball, 12 handball and 14 volleyball players. All players belonged to the teams of the Sports Club of Tartu University and participated in Estonian Championships.

Tartu University Ethics Committee for research involving human subjects approved the study. All participants received verbal and written information about the study and gave an informed written consent before anthropometrical and body composition assessment. This consent included the opportunity for the players to read the manuscript to be submitted for publication. Additional background information was provided by each player, including her date of birth, team sports, and playing experience. The anthropometrical parameters and body composition were measured before motor ability tests.

Measurement of anthropometrical parameters and body composition
Body height and arms' span was measured (Martin metal anthropometer) to the nearest 1.0 cm. Body mass was measured (medical electronic scale; A&D Instruments Ltd, Abingdon, UK) to the nearest 0.05 kg. The body mass index (BMI $kg \cdot m^{-2}$) was calculated. Body fat %, fat mass in kilograms, lean body mass in kilograms, fat-free mass in kilograms and BMC in kilograms were measured. Total body composition (lean mass, fat %, and BMC) was evaluated by means of DXA using a total body scanner (QDR Explorer W, Hologic, MA, USA). Whole body scanning time was about seven minutes. Fat mass (kg) was calculated as fat % from body mass. Fat-free mass (kg) was calculated as difference between body mass and fat mass. To ensure consistency all scanning and analyses were performed at the Laboratory of Kinanthropometry at the Institute of Sport Pedagogy and Coaching at Tartu University by the same investigator.

Measurement of motor abilities
The motor ability tests were selected to take into consideration the demands of all three team sports. Some of them are more important in each studied team sports.

The following motor ability tests were used:
Vertical jump (cm) on contact platform (Newtest OY, Finland).
* with hands on hip (Squat jump – SJ) (Hara et al. 2005, Granados et al. 2007). From standing position, legs in semi-squat position, arms placed on the hips. Subjects performed three jumps with recovery time between each jump and the highest was used in data analyses.
* with arms' swing (counter-movement jump – CMJ) (Vicente-Rodriguez et al. 2004, Vila et al. 2012). Hara et al. (2005) found that total work done by all the joints increased significantly with arms' swing: 34% of this increase came from upper extremity joints and 66% from the lower extremity joints. In the present study the players were asked to perform a maximal jump with arms' swing on the contact platform from the semi-squat position followed by an immediate attempt to jump as high as possible with an arms' swing.

Shuttle run, 10x5m (s) was used to estimate agility and specific speed (Lidor et al. 2005). The distance of 5m was marked on the floor. The subjects were required to run the distance of 5m back and forth ten times in all. After each 5m distance the participant had to cross over a line with both feet. After the last 5-meter-run, when returning to the starting point, the time was recorded by the experimenter using a handheld stopwatch with 0.01s accuracy.

Medicine ball (1kg) over-arm throws (m) with dominant and non-dominant hand from sitting position. Medicine ball (1kg) throw was used to assess explosive power of the shoulder. Different medicine ball throw tests have been used to assess the dynamic strength and muscular power of the upper extremities (Lidor et al. 2005; Debanne & Laffaye, 2012). The subjects threw a 1-kg medicine ball as far as they could. The medicine ball was thrown over-arm with dominant and non-dominant hand from the sitting position. Both legs were stretched out behind the throwing line. Each subject performed 3 trials, the best was used in further analyses.

Suicide Run (Delextrat & Cohen) is a test commonly used in basketball to assess the anaerobic capacity of the players. Anaerobic capacity is essential in handball and volleyball too. The players were asked to run continuously 143.3m at maximum speed with several changes of direction.

Pass the ball on speed and precision. A line for making the pass was drawn on the floor 3m from the wall and a 40x40 cm square was drawn on the wall with the lower side at 180cm from the floor. Subjects were standing behind the line for the pass in a comfortable catching-passing position and were passing on the target on the wall with maximum speed and precision during 30s. All subjects performed the test with a basketball (catch and pass with two hands at the chest), a handball (catch with two hands and over-arm pass with the dominant hand) and a volleyball (two hand over-arm pass). Passes with three balls were compounded. Two investigators recorded all passes that the subjects performed during the 30s and the passes performed accurately on the target. All performed passes were recorded as passes on speed and passes that were on the target were recorded as precision passes. The same investigators recorded the tests with all subjects and all tests were performed in the same place.

Statistical analysis

The analysis was conducted using SPSS version 10.0 statistical software program (SPSS Inc., Chicago, IL). Standard statistical methods were used to calculate mean ($\overline{X}$) and standard deviation (± SD). Statistical comparisons between the groups were made using one-way analyses of variance (ANOVA) together with Tukey HSD post-hoc test. Pearson correlation coefficients were used to determine the relationships between dependent variables. The stepwise multiple regression analysis was used to determine the effect of morphological parameters on the motor abilities. The α level of 0.05 was used for all statistical tests

Results and discussion

Anthropometrical parameters, body composition and motor abilities of amateur female basketball, handball and volleyball players

Mean anthropometrical parameters and statistically significant differences between basketball, handball and volleyball players are presented in table 1. The results of the present study demonstrated that anthropometrical parameters and body composition indices differed significantly between the three female team sports players. Amateur handball players were significantly shorter and with shorter arms' span than basketball and volleyball players. In body mass, BMI, fat mass the differences between basketball, handball and volleyball players were not significant. Volleyball players were the tallest, with the longest arms' span. In earlier studies (Schaal et al. 2013) emphasize the importance of an increased stature for volleyball performance too. Handball players had significantly lower amount of body lean mass, fat free mass, BMC than volleyball players and were with highest body fat%. Higher body fat for basketball (Delextrat & Cohen, 2009) and handball players could be advantageous as they experience a lot of physical contact. The differences between morphological characteristics of amateur basketball and volleyball players were not significant. It is interesting to note that in most morphological characteristics handball players indicated lower indices than the means of the total sample. To a large extent results of the present study coincide with an earlier study with Greek female handball, basketball and volleyball players (Bayios et al 2006).

Comparing the results of female amateur basketball, handball and volleyball players motor abilities (table 1) indicated that volleyball players demonstrated better results in all tests except in medicine ball over-arm throw with dominant hand and in pass on speed. Volleyball players achieved significantly better results in SJ, CMJ and in 10x5m compared with basketball and handball players. This may be explained by the fact that vertical jump, short bursts and changes of direction at high speed are typical for volleyball. At the same time in basketball and handball, players perform mostly jumps with take-off from one-foot and change of direction movements are longer in comparison with volleyball. Results showed that handball players demonstrated best results only in medicine ball over-arm throw with dominant hand. This explains game-specific actions in handball – shots and passes with dominant hand. In medicine ball over-arm throw with non-dominant hand volleyball players show significantly better results compared with handball players and the difference between results of throw with dominant and non-dominant hand was not as big as for handball and basketball players because in volleyball passing is done mostly with two hands. Basketball players pass significantly faster and significantly more precisely compared with handball players. Results of present study did not indicate significant differences in anaerobic capacity (Suicide run). Results of the present study showed the effect of certain team sports on motor performance while the morphological characteristics of players do not contradict the demands of relevant team sports.

Table 1.
Anthropometrical parameters, body composition and motor abilities of amateur female basketball, handball and volleyball players.

		Basketball players(n=13)	Handball players (n=12)	Volleyball players (n=14)	Total sample (n=39)
		$\overline{X}$ ±SD	$\overline{X}$ ±SD	$\overline{X}$ ±SD	$\overline{X}$ ±SD
ANTHROP	Height (cm)	***174.85± 6.04 #***	**168.17± 5.97 &**	177.36± 4.63	173.69 ± 6.65
	Mass (kg)	66.00± 7.33	64.00±11.13	71.29± 6.08	67.28 ± 8.68
	Arms span (cm)	***176.00± 4.65 #***	**169.83± 7.12 &**	180.36± 6.22	175.67 ± 7.32
BODY COMPOSITION	BMI	21.57± 1.53	22.67± 3.24	22.66± 1.73	22.30 ± 2.25
	Fat%	24.94± 4.42	28.36± 3.39	25.71± 3.53	26.27 ± 3.98
	Fat mass (kg)	16.68± 4.64	18.15± 5.19	18.41± 4.30	17.75 ± 4.64
	Lean mass (kg)	46.45± 3.09	**42.64± 6.60 &**	49.61± 3.08	46.41 ± 5.21
	BMC (kg)	***2.83± 0.29 #***	**2.50± 0.32 &**	2.84± 0.19	2.73 ± 0.30
	Fat free mass (kg)	49.28± 3.30	**45.14± 6.84 &**	52.44± 3.12	49.14 ± 5.42
MOTOR ABILITIES	SJ (cm)	28.38± 3.38	**27.42± 3.63 &**	**31.93± 3.87 ¤**	29.36 ± 4.06
	CMJ (cm)	33.62± 3.55	**32.17± 5.42 &**	**38.36± 4.38 ¤**	34.87 ± 5.14
	Med-ball dom hand (m)	8.26± 0.86	8.43± 1.04	8.00± 0.94	8.22 ± 0.94
	Med-ball non-dom hand	5.90± 0.60	**5.48± 0.72 &**	6.04± 0.39	5.82 ± 0.61
	10x5m (s)	18.23± 0.47	**18.36± 0.49 &**	**17.66± 0.58 ¤**	18.07 ± 0.59
	Suicide run (s)	33.40± 1.56	34.45± 1.49	33.33± 1.16	33.70 ± 1.46
	Pass speed (x)	***67.77± 6.41 #***	61.50± 4.46	65.21± 6.74	64.92 ± 6.38
	Pass precision (x)	***54.08± 7.15 #***	**43.92± 9.28 &**	56.71± 8.33	51.90 ± 9.75

significant differences between basketball and handball players; **&** significant differences between volleyball and handball players; ¤ significant differences between volleyball and basketball players; $p < 0.05$

Relationship of motor abilities with morphological characteristics in female basketball, handball and volleyball players

Relationships between motor abilities and morphological characteristics are presented in table 2. The results of the present study demonstrated that few significant correlations between motor performance results and morphological characteristics in studied amateur female basketball, handball and volleyball players existed. Only negative correlations between motor abilities and morphological characteristics in basketball players were determined. Suicide run had significantly negative correlation with most morphological characteristics (r = 0.62-0.85). Significantly negative relationship (r = -0.56 – -0.69) existed for pass on speed and precision with body composition components which may be explained by insufficient practice of the basketball players studied. Significantly positive relationship existed between morphological characteristics and medicine ball over-arm throw with dominant hand (r = 0.62 – 0.80) and pass on speed and precision with BMC (r = 0.66 – 0.70) in handball players. This is in accordance with playing actions in handball. Volleyball players showed only two significant relationships between motor abilities and morphological characteristics – 10x5m run with body height (r = 0.61) and Suicide run with arms´ span (r = 0.55). Boldt et al. (2011) in study with female volleyball players measured anaerobic power with verical jump, standing long jump and t-test. They found that body composition has little influence on anaerobic power too.

Table 2.

Relationship between motor abilities and morphological characteristics ($p < 0.05$)

		SJ	CMJ	MB DH	MB NDH	10x5m	SUICIDE	PASS SPEED	PASS PREC
Height	Basketball	-0.58	-0.42	-0.24	-0.05	0.35	0.71	-0.34	-0.39
	Handball	0.23	0.37	**0.73**	**0.61**	-0.17	-0.20	0.37	0.41
	Volleyball	-0.22	-0.13	0.26	-0.08	0.61	0.51	0.05	-0.03
Body mass	Basketball	-0.50	-0.49	-0.44	-0.13	0.43	**0.85**	**-0.60**	**-0.56**
	Handball	0.00	-0.01	0.62	0.44	0.14	0.27	0.42	0.43
Arms' span	Handball	0.32	0.39	**0.70**	**0.58**	-0.10	-0.13	0.34	0.32
	Volleyball	-0.07	0.05	0.20	0.12	0.53	0.55	-0.04	-0.07
BMI	Basketball	-0.45	-0.34	-0.45	-0.15	0.29	**0.62**	**-0.58**	-0.47
	Handball	-0.13	-0.20	0.37	0.22	0.22	0.39	0.70	0.66
Fat%	Basketball	-0.50	-0.33	-0.28	-0.07	0.38	0.72	-0.33	-0.32
	Handball	-0.18	-0.34	0.02	-0.01	0.30	**0.60**	0.16	0.14
Fat mass	Basketball	-0.58	-0.45	-0.40	-0.12	0.43	0.79	-0.45	-0.45
Lean mass	Basketball	-0.44	-0.54	-0.55	-0.19	0.37	**0.79**	**-0.69**	**-0.62**
	Handball	0.06	0.10	0.72	0.51	0.11	0.15	0.41	0.45
BMC	Basketball	-0.13	-0.32	-0.61	-0.31	0.29	0.37	**-0.57**	**-0.59**
	Handball	0.25	0.35	**0.80**	0.39	-0.07	-0.13	**0.70**	0.66
Fat-free mass	Basketball	-0.42	-0.53	-0.57	-0.20	0.37	**0.77**	**-0.69**	**-0.63**
	Handball	0.07	0.11	**0.73**	0.51	0.11	0.14	0.43	0.47

For stepwise multiple regression analyses (table 3) motor abilities were selected as dependent variables and morphological characteristics as independent variables to determine the impact of morphological characteristics on motor abilities of amateur female basketball, handball and volleyball players. Some motor abilities in the basketball players' group were predicted by morphological characteristics. Body mass showed the greatest negative influence on Suicide run – 68.92% (R^2 x 100; $p<0.001$). From studied morphological characteristics fat-free mass influenced by 48.67% (R^2 x 100; $p<0.007$) medicine ball over-arm throw with dominant hand and BMC had positive influence on pass on speed (41.61%) and precision (39.18%) among handball players. Results of earlier studies confirm influence of body composition on over-arm throw (Van den Tillaar & Ettema, 2004, Van den Tillaar & Cabri, 2012). Body lean mass had great influence on pass on speed – 43.39% (R^2 x 100; $p<0.018$) in volleyball players.

Table 3.
Stepwise multiple regression with motor abilities as dependent variables and morphological characteristics as independent variables

Dependent variable	Sample	Independent variable	R^2 x 100 %	F	p
SJ	**Basketball** (n = 13)	**Fat mass**	**27.99**	5.67	**< 0.037**
	Handball (n = 12)	Arms´ span	1.48	1.17	< 0.306
	Volleyball (n = 14)	BMI	4.81	1.66	< 0.223
CMJ	Basketball (n = 13)	Lean mass	22.83	4.55	< 0.057
	Handball (n = 12)	Arms´ span	6.76	1.80	< 0.210
	Volleyball (n = 14)	BMC+Fat %	25.40	3.21	< 0.079
MB DH	**Basketball** (n = 13)	**BMC**	**31.91**	6.62	**< 0.026**
	Handball (n = 12)	**Fat-free mass**	**48.67**	11.43	**< 0.007**
	Volleyball (n = 14)	Fat %	1.60	1.21	< 0.293
MB NDH	Basketball (n = 13)	BMC	9.77	1.19	< 0.299
	Handball (n = 12)	**Body height**	**30.56**	5.84	**< 0.037**
	Volleyball (n = 14)	BMI	7.00	1.98	< 0.185
10 x 5m	Basketball (n = 13)	Fat mass	10.83	2.46	< 0.146
	Handball (n = 12)	-	-	-	-
	Volleyball (n = 14)	**Body height**	**32.16**	7.16	**< 0.021**
SUICIDE RUN	**Basketball** (n = 13)	**Body mass**	**68.92**	27.62	**< 0.001**
	Handball (n = 12)	**Fat %**	**29.22**	5.54	**< 0.041**
	Volleyball (n = 14)	**Arms´ span**	**23.94**	5.09	**< 0.044**
PASS on SPEED	**Basketball** (n = 13)	**Fat-free mass**	**42.86**	10.00	**< 0.009**
	Handball (n = 12)	**BMC**	**41.61**	5.61	**< 0.027**
	Volleyball (n = 14)	**Lean mass**	**43.39**	5.98	**< 0.018**
PASS on PRECI-SION	**Basketball** (n = 13)	**Fat-free mass**	**34.88**	7.43	**< 0.020**
	Handball (n = 12)	**BMC**	**39.18**	4.54	**< 0.044**
	Volleyball (n = 14)	**Lean mass**	**34.47**	8.78	**< 0.026**

Conclusion

In conclusion the present study showed:

1. The morphological characteristics of amateur female volleyball players were more in accordance with the demands of competitive volleyball and they showed better results in most motor ability tests in comparison to handball and basketball players.
2. Amateur female handball players had lower indices in most morphological characteristics and motor ability results in comparison to volleyball and basketball players.
3. Morphological characteristics impacted negatively the results of all motor ability tests of the studied basketball players.
4. There are some limitations to the present study. The sample for investigation consisted from 12-14 players in each team sports only. Further investigations are necessary for more detailed and objective results.

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TESTING GAME-BASED PERFORMANCE IN TEAM HANDBALL

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Summary
The aim of this study was (1) to develop a team-handball game based performance test including similar movements and intensities as in competition, (2) to determine the validity of this test and (3) to measure its test-retest reliability using physiological and biomechanical variables. For the test-retest reliability, we found an ICC>.70 for the maximal LA and HR, mean offense and defense time as well as ball velocity that yielded an ICC>.90 for the VO_2peak in the game based test. Percent walking and standing constituted 73% of total time. Low (18%) and high (9%) intensity running in the game based performance test was similar to competitive games suggesting the game based performance test is a valid test to assess performance in team-handball.

Keywords
Peak oxygen uptake and lactate, offence and defense time, ball velocity, test-retest reliability, validity

Introduction
Team-handball is an Olympic sport characterized by fast paced defensive and offensive actions during a game. These actions include specific movements of passing and catching a ball, throwing, jumping, screening, blocking, fast accelerations and decelerations including stops, changes of directions and frequent changes with low intensity movements as in standing, walking and jogging. To determine performance in team-handball, previous studies used general or specific endurance tests, strength tests, jumping and sprinting tests and throwing analyses. Most of these tests were performed stepwise under standardized conditions (Gorostiaga et al., 2005; Buchheit, 2008; Buchheit, 2010). A team-handball performance test including all of the team-handball specific movements is lacking, although the frequent changes of these movements and intensities determine the load of this complex sport.

Over the course of a game, movements in team-handball can be characterized mostly by short accelerations (0-3m) with stops (30-40 per game) and changes in direction (30-40 per game) and less by sprints (10-30m). Typically, a team-handball player walks and stands still ~70% of the time while fast running and sprinting comprises only of ~4% of the total playing time. The rest of the time is spent performing throws, passes, jumps, light and hard body checking, and screenings in offense and defense during a game (Michalsik et al., 2011a; Michalsik et al., 2011b; Michalsik et al., 2012; Povoas et al., 2012). Testing specific performance in team-handball should therefore include mainly short accelerations with numerous stops and changes in direction, throws, passes, jumps, light and hard body checking as well as screens and fewer sprints between 10 and 30m.

The aim of this study was (1) to develop a team-handball game based performance test including similar movements and intensities as in competition, (2) to determine the validity of this test and (3) to measure its test-retest reliability using physiological and biomechanical variables.

Methods
Seventeen experienced team-handball players (mean ± SD for age: 23 ± 3 years; height: 1.87 ± 0.06 m; weight: 85 ± 10 kg; training experience: 12 ± 3 yrs; 5 wing, 9 backcourt players, 3 pivot, 13 right and 4 left handed player) and 2 experienced goalkeepers participated in the study. All subjects were physically healthy, in good physical condition, and reported no injuries during the time of the study. The local ethics committee approved the study and all subjects signed the informed consent.

The study consisted of two game based performance tests, an incremental treadmill-running test and a team-handball test game. To determine the test-retest reliability, all subjects performed two game based performance tests separated by seven days between the first and the second test. One day after the first game based performance test, subjects performed an incremental-treadmill running test. We selected the incremental-treadmill running test because this test is frequently used to determine physiological performance in team-handball. One day after the second game based performance test, the team-handball test game (12 subjects and 2 goalkeepers) was performed. The team-handball test game was used to measure the similarities of intensities during the game based performance test and those during competition.

Table 1. Sequencing of the game based performance test

	Heat 0	Heat 1	Heat 2	Heat 3	Heat 4	Heat 5	Heat 6	Heat 7	Heat 8
Defense #1	3 tackles	3 tackles	3 tackles + screen	3 tackles	3 tackles	3 tackles	3 tackles	3 tackles	3 tackles + screen
Break	15s			15s	15s		15s		
Defense #2	3 tackles + screen			3 tackles + screen	3 tackles		3 tackles + screen		
Defense to Offence	20s fast break + low int.	20s moderate intensity	20s moderate intensity	20s fast break + low int.	20s moderate intensity	20s moderate intensity	20s fast break + low int.	20s moderate intensity	20s moderate intensity
Offence #1	5 passes	5 passes	4 passes + throw	5 passes	5 passes	5 passes	5 passes	5 passes	4 passes + throw
Break	15s			15s	15s		15s		
Offence #2	4 passes + throw			4 passes + throw	4 passes + throw		4 passes + throw		
Offence to Defense	20s moderate intensity	20s moderate intensity	20s moderate intensity	20s moderate intensity	20s sprinting + low int.	20s moderate intensity	20s sprinting + low int.	20s moderate intensity	20s moderate intensity
Lactate measure	40s	40s	40s	40s	40s	40s	40s	40s	40s

To familiarize players with the standardized movements (offensive and defensive actions) utilized in the game based performance test, all subjects were acquainted with these movements in two training courses one week before the first test. The study was timed during the preparation phase of the teams five weeks after the start of training to prevent the influence of the games during the championship and to enable each player time to achieve a good training level prior to testing. Twelve subjects performed all tests and the team-handball test game. Five subjects performed only three tests.

In the game based performance tests the subjects performed 8 heats (and a warm-up heat) with a 40s break between every heat (to obtain blood lactate). Every heat consisted of a defense, defense-to-offence, offence and offence-to-defense section (Table 1). In the defense section the subjects have to perform alternate light and hard checking against a mat roll to simulate the defensive movements in team-handball competition (Fig. 1). In the offence section they have to perform strike movements including catching and passing a ball, fast change of directions and jump throws (not in all offence sections). Offence and defense movements were standardized by fixed positions of the touching fields that have to be touched by the subjects and fixed positions of the mat rolls (Fig. 1).

Oxygen uptake and heart rate (HR) was measured via a portable gas analysis system in breath-by-breath mode ($K4b^2$, Cosmed, Rome, Italy). Peak oxygen uptake (VO_2peak) and the HR were defined and corresponding HR for each heat in the game based performance test and the VO_2peak and HR during the entire incremental treadmill-running test. Blood lactate (LA) was measured using 20µl capillary tubes utilizing fully enzymatic amperometric measuring system (Biosen 5040, EKF diagnostics, Leipzig, Germany). Maximal LA measurements were obtained at the end of the game based performance test, and again after 2min of the last measurement in heat 8 that was found to be optimal as determined during the pre-test. Sprinting time during the game based performance test was measured using a Brower timing system (Brower Timing System CM L5, Brower, Utah, USA). Light barriers were placed on both 9m-lines and in the middle line of the team-handball field to measure the 11m-sprinting time during the fast break (heat 3 and 6) and the sprint from offense-to-defense (heat 4 and 6). To determine the position and the running speed of subjects during the game based performance test, a local positioning measurement system (Inmotiotec, Abatec, Regau, Austria) was used. Ike Master software (Ikemaster 2004, IKE Software Solutions, Salzburg, Austria) was used to calculate offence and defense time. During the entire game based performance test and the team-handball test game percentage (low: 0-2 $m.s^{-1}$; moderate: 2-4 $m.s^{-1}$; high: >4 $m.s^{-1}$) of the local position measuring speed was calculated to determine playing intensity. Playing intensity during the team-handball test game was calculated excluding the breaks during LA measurement. Ball velocity (and jump height) was measured by calculating linear velocity (and flight time) of the 2D-position of the center of the ball at ball release (last to first foot contact) utilizing PeakMotion (PeakMotion 8.1, Vicon Peak, Oxford, UK). To enable the accuracy in calculating ball velocity (and jump height) we used a Basler high-speed camera (Basler piA640-210gm, Basler AG, Ahrensburg, Germany).

The incremental running tests started with an initial treadmill speed of $6km.h^{-1}$ (5min constant running) on a motorized treadmill (hp Cosmos Saturn, hp Cosmos, Traunstein, Germany). The test increased by $1.5km.h^{-1}$ every minute until volitional exhaustion. Initial speed, increment speed, and percent grade were selected to ensure a total testing time of 8-12min to determine VO_2peak during the incremental treadmill-running test (Howley et al., 1995).

In the team-handball test game, all players played without changes in the game. Therefore, the playing time was reduced to 20 min per halftime. Since game intensity is influenced by defensive tactics, a 6:0-defense was played in the first half and a 3:2:1-defense was played in the second half by both teams. The test game was conducted by an official referee and assisted by an official timekeeper and a secretary. The playing score was 8:9 at the half time and 18:19 at the end of the test game. During the test game HR and the local positions of the 12 players was determined. LA during the game was measured before warm up and immediately before starting the game, after every 5min during the game (the game was interrupted every 5min), after the first half, at the end of the half-time break (10min), after the second half (end of the game) and 1, 3 and 5min after the end of the game. During the team-handball test game, HR was recorded with the Suunto Team Manager (Suunto, Vaanta, Finnland). Peak HR (HR_{peak}) of the test game was defined as the HR_{peak} for each phase (every 5min) during the team-handball test game.

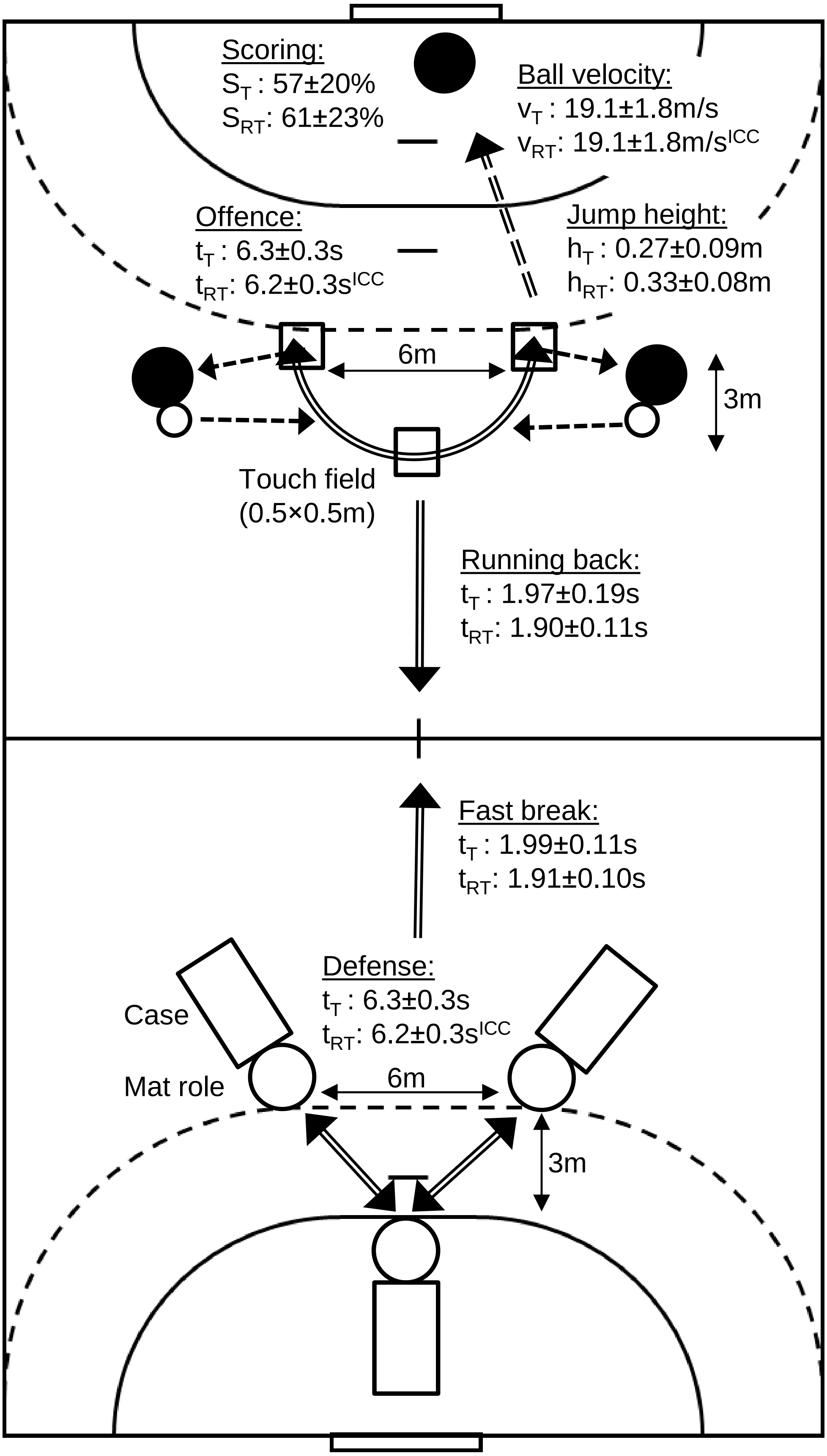


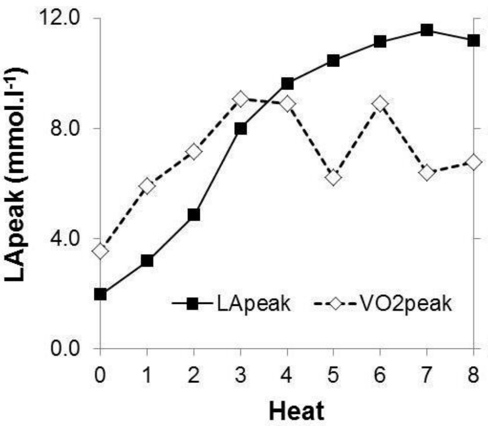
Figure 1. *Schematic diagram of the game based performance test and mean ± SD for the offence and defense time, fast break and running back time, ball velocity, scoring percentage and jump height in the test ($_T$) and retest ($_{RT}$). (^{ICC}: ICC>0.70 and CV<5%).*

All statistical analyses were conducted using SPSS ver. 20.0 (IBM Corp., Armonk, NY, USA). Means and standard deviations (± SD) of the variables were calculated for descriptive statistics. Interclass-correlation coefficient (ICC (2, 1), two-way random effects model with single measure), 95% confidence interval and coefficient of variation (CV) were calculated to determine the test-retest reliability. We considered an ICC>0.70 and a CV<5% as reliable. To determine the validity of the game based performance test the Pearson Product-Moment correlation between (1) the game based performance test and the incremental treadmill-running test for the $VO2_{peak}$, (2) between the game based performance test and the team-handball test game for HR_{peak} and LA_{peak} as well as (3) the differences (two-way ANOVA with repeated measures) of playing intensities and tests (game based performance test; test game first and second half) were calculated.

Results

The mean ±SD of LA and $VO2_{peak}$ for each heat in game based performance tests is shown in Figure 2. The Pearson Product-Moment correlation revealed a significant correlation for $VO2_{peak}$ (*r* =0.58, P<0.05) and HR_{peak} (*r* =.70, P<0.01) between the game based performance test and the incremental treadmill running test as well as for LA_{peak} (r =0.62, P<0.05; r= 0.80, P<0.01) and HR_{peak} (r =0.63, P<0.05; r= 0.77, P<0.01) between the game based performance test and the first or second half of the team-handball test game.

Comparing the playing intensities in the game based performance test and the team-handball test game (Fig. 3) we found a significant difference between playing intensities, F (33,2) = 6879.49, P<0.001, η2=0.99 as well as for the interaction in playing intensity × test, F (62,4) = 7.97, P<0.001, η2=0.40, but no significant difference between the game based performance test and the first and second half of the team-handball test game, F (32,2) = 0.00, P = 1.00, η2 = 0.00.



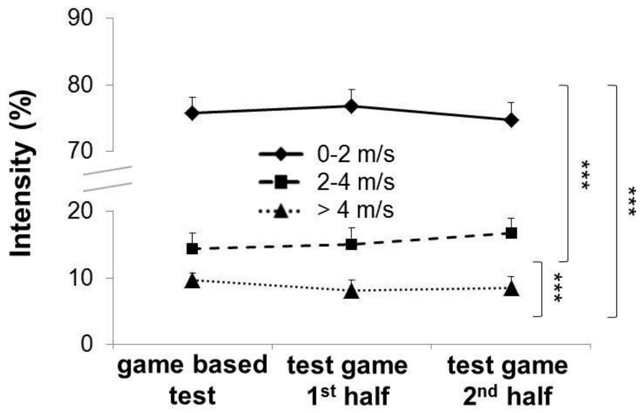


Figure 2. *LA_{peak} and $VO2_{peak}$ in the game based performance test*

Figure 3. *Percentage of intensities in the game based performance test and test game*

Discussion

The innovative aspect of this study was developing a test that enables measuring physiological and biomechanical variables under conditions similar to team-handball competition. Comparing playing intensities during the game based test and the team-handball test game, it was found that the percentage for low (standing and walking), moderate (jogging and slow running) and high intensities (fast running and sprinting) was not significantly different from the test game. Similar playing intensities were also found when (Michalsik et al., 2012) analyzed match performance in elite Danish team-handball players. Comparing the physiological variables, we found a correlation for LA_{peak} and HR_{peak} during the game based test and the first and second half of the team-handball test game. A correlation was also found for $VO2_{peak}$ and HR_{peak} between the game based performance test and the incremental treadmill running test. We suggest that the game based performance test is very well suited to measure team-handball performance and closely reflects performance in an actual team-handball competition.

To validate the team-handball game based performance test we utilized a test-retest design with a seven day separation between the test and retest. A high reliability (ICC>0.70 and CV<5.0%) was found for $VO2_{peak}$, HR_{peak}, offensive and defensive time and ball velocity. Scoring percentage was strongly influenced by the goalkeeper (when the goalkeeper prevented scoring), jump height was adapted to the different situations (run up, catching the ball and position of the goalkeeper) and sprinting time (fast break and running back) was influenced by different accelerations when starting the sprint that explained the partial reliability of these variables. A limitation of this study was that running velocity was not standardized. Subjects were instructed to move as fast as possible in the offense and defense section, to sprint maximally in the fast break and running back and to jog at a moderate level when changing from offense to defense or vice versa. The high motivation of subjects due to the specificity of the test motivated players to give it their personal best in offense and defense. We found only a mean difference of 0.1s between test and retest in the offense and defense time.

In conclusion, we found that the team-handball game based performance test is a valid and reliable test to analyze team-handball performance (physiological and biomechanical variables) under conditions similar to competition. We propose using this type of game based test for team-handball players of different experience level, age and sex. Additional studies are warranted to ascertain variables that may contribute to the knowledge base of this type of tests.

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RELATIONSHIPS BETWEEN PSYCHOLOGICAL, TACTICAL, TECHNICAL, AND PHYSICAL CHARACTERISTICS OF YOUNG FEMALE HANDBALL PLAYERS

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Summary
Our aim was to study the relationships between some important psychological characteristics, technical and tactical skills, and physical characteristics of young female handball players. The subjects were 79 female players aged 12-14 from 6 handball teams. Factor analysis and frequency analysis were applied. Applications of those findings and their consequences for coaching practice are discussed.

Narrow specialization is characteristic of modern science; at the same time, sport practitioners should focus on variety of research and integrate disparate findings in their everyday work with players. We believe that the time is ripe for the implementation of complex research in sports, integrating approaches of the different sport sciences in order to maximize the scientific and practical effects. Studies on physical qualities, on technical and tactical skills and at the same time – on psychological characteristics of players are essential in contemporary handball. However, our inquiry of available literature showed the presence of only one published integral study in basketball (Tsvetkov, 1985); we have not been able to identify similar studies in handball. The total absence of such initiatives on the background of the great necessity of this type of research inspired us to undertake the present study.

Keywords
Tactical skills, technical skills, physical characteristics, motivation, personality

Objective
Our aim was to study the relationships between some important psychological characteristics, technical and tactical skills, and physical characteristics of young female handball players (12-14).

Method
Sample
The subjects were 79 female players aged 12-14 from 6 handball teams, ranked amongst the first 8 teams in the country.

Instruments and variables
The following psychological characteristics were studied: 1. Characteristics of the achievement motivation - *Hope for success* and *Fear of failure* - measured *by AMS-Sport* (Elbe & Wenhold, 2005; Bulgarian adaptation by Zsheliaskova-Koynova, 2012*)*; 2. Temperament characteristics *Extroversion* and *Neuroticism* - measured by *EPQ* (Eysenck & Eysenck, 1975*;* Bulgarian adaptation by Paspalanov, Shtetinski & Eysenk, 1984).

The *self-assessment of the tactical skills* was measured by *TACSIS* (Elferink-Gemser et al., 2004; Bulgarian adaptation by Zsheliaskova, Bozhilov, & Yordanov (2009). In this study we used the total score on the whole test (rather than the score on each of the four scales separately). *Tactical skills* were also measured *by the coaches* who used 10 categories to

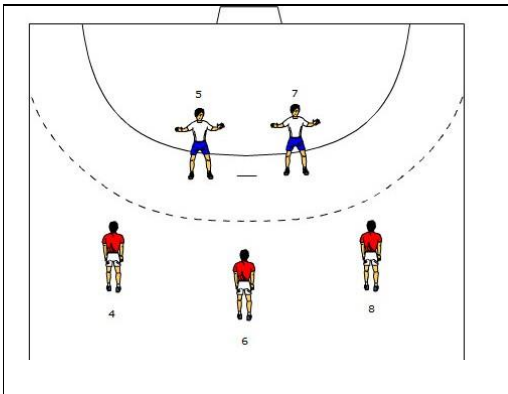
assess every handball player – play in defence and offence, interactions with other players, anticipation, situation reading, etc. (Zsheliaskova-Koynova, 2011).
For example:

The skills of the player to foresee the development of the situation are:

Very weak 1 2 3 4 5 6 Excellent

The final score is calculated as the sum of the 10 assessments.

Decision making in tactical situations was measured by the *specific test for handball* (Varbanov, 2012), that consist of 9 game situations (individual, group or team situations) of numerical minority, equality and superiority, where the player should write out and/or draw her solution. For example:

	3rd situation: Please indicate which player has the ball and how will the situation develop.

Every solution is estimated as: best (3 points), good (2 points) or satisfying (1 point). If there is no solution of the situation, it is estimated with 0 points. The final score is the sum of the points given for the solutions of all 9 situations. *Dribble technique* was measured by the test *30 m dribbling with the strong hand*. *Speed* was measured by the test *30 m running from standing position*. *Explosive power of the upper limbs* was measured by the test *Throwing handball ball from standing position. Height* and *weight* of the players were also measured. The data of *birthdays* of the players were processed by frequency analysis in order to identify eventual existence of RAE (relative age effect).

Procedure
All physical tests, self-assessment of the tactical skills and the test measuring decision making were completed during few training sessions at the end of the preparation phase. Psychological tests were completed before practice during the competitive period. Tactical skills were assessed by coaches during the competitive period.

Statistical analysis
The data were analyzed using SPSS version 15.0. by factor analysis (method of principal components). Factor loadings above 0.400 were defined as statistically significant. Frequency analysis was also used.

Results and discussion
Four factors with eigenvalues above 1 have been identified as a result of the application of the factor analysis. These four factors explain 73.26% of the variance. Factor 1 (eigenvalue 2.92) explains 24.4% of the variance; factor 2 (eigenvalue 2.09) explains 17.4 % of the variance; factor 3 (eigenvalue 1.51) explains 12.6% of the variance; and factor 4 (eigenvalue 1.22) explains 10.2% of the variance (Table 1).

Table 1. *Factor loadings*

	Factor 1	Factor 2	Factor 3	Factor 4
Explosive power of the upper limbs	**.840**	.129	-.219	
Height	**.657**	.285	.380	.271
Weight	**.652**	.198	**.520**	
Tactical skills (assessment of the coaches)	**.488**		.380	**-.562**
Tactical skills (self-assessment)	**.474**	**-.481**	**-.439**	-.256
Speed	**-.455**	.284	**.739**	
Dribble technique	**-.456**	.180	**.724**	.182
Neuroticism	**.420**	**-.594**	.195	
Extroversion	.253	.103	-.154	**.780**
Fear of failure	-.132	**-.767**	.297	.110
Decision making in tactical situations	.102	**.558**	**-.485**	-.365
Hope for success		**.451**		

Note. Zeroes before the decimal points and factor loadings under 0.100 are omitted.

High factor loadings on factor 1 have 8 variables: weight and height, explosive power, tactical skills (both self-assessed and assessed by the coaches), neuroticism, speed and dribble technique (the signs before the loadings of the last two variables are negative, because lower times indicate higher speed and better technique). The complex of characteristics that are interwoven here suggest the name of the factor – *"Acceleration"*. The significant loading of neuroticism on the first factor indicates that this is not just the case of higher and hence heavier girls (it is well known that during puberty neuroticism raises and after the end of this period it decreases back). That is, about ¼ of the variance is explained by the accelerated psychosexual maturation leading to higher speed and power, better technique and tactical skills, higher self-estimations. Maturation is an important factor that affects all anthropometric characteristics of young handball players (Matthys, 2012; Matthys et al., 2013; Mohamed et al., 2009). The higher level of skills and qualities that are related to the higher biological age makes coaches to prefer more matured girls during the selection phase; also, as more mature girls show better results, auto-selection process works in the same direction too.

Additional evidence in this direction was the frequency analysis of the birthdays of players. It showed that 40.8% of the girls are born in the 1st quartile, 26.3% - in the 2nd quartile, 18.4% in the 3rd quartile, and 14.5% of the players - in the last quartile. With 67.1% players born in the 1st half of the year, and 2.8 times more players born in the 1st quartile compared to the players born in 4th quartile, RAE is quite pronounced in the studied sample of young handball players. This result shows that coaches indeed prefer to select more mature girls for their teams.

High factor loadings on factor 2 have 5 variables – fear of failure (with negative sign), neuroticism (with negative sign), decision making in tactical situations, self-assessed tactical skills (with negative sign) and hope for success. As here are represented both motivational characteristics, we decided to name the factor *"Achievement Motivation".* The fear of failure and neuroticism are related to decreased performance in decision making test, and striving for success is related to more qualitative thinking of the young players. Negative influence of neuroticism and fear of failure on the achievement tests is well studied and documented (Ahmad & Rana, 2012; Chamorro-Premuzic et al., 2003, 2004, 2006; De Read and Schounwenberg, 1996; Di Fabio & Palazzeschi, 2009; Petrides et al., 2005). High neuroticism can potentially worsen thinking functions and cognition such as academic achievement (Ackerman & Heggested, 1997). Similar results are obtained in studies on national female teams of basketball and handball – lower neuroticism and higher hope for success are related to higher game effectiveness (Zsheliaskova-Koynova & Varbanov, 2012; Zsheliaskova-Koynova & Todorova, 2012).

The negative sign of the factor loading on the 2nd factor of the self-assessed tactical skills is a new phenomenon for us. It seems that achievement motivation characteristics influence in different ways decision making and self-assessment of the tactical skills: fear of failure and neuroticism worsen decision making and improve self-assessment of tactical skills while the opposite is true for hope for success. We would suppose eventual compensation mechanism in the case of neurotic players with higher fear of failure. This phenomenon needs additional exploration in order to be properly understood.

High factor loadings on factor 3 have 5 variables – speed, dribble technique, weight, decision making in tactical situation (with negative sign) and self-assessed tactical skills (with negative sign). The name we have chosen for this factor was *"Speed"* as it includes speed of physical actions and of tactical decisions. Different types of speed are not necessarily correlated, but in this age period physical and mental speed are closely related in the studied sample. Girls who are lighter have greater speed in their actions and decision making and estimate higher their tactical skills. At the opposite, girls with higher weight (but not height at the same time) are slower in their movement with and without ball, in decision making and estimate lower their own tactical skills. This finding raises some questions about selection principles but it should be noted that these heavier girls seems to be necessary in their teams because they successfully execute other important game functions. For example, Matthys (2012) found significant differences between playing positions: the relative early maturing, tall and strong players played as keeper or back, the relative late maturing and small players as wing and the handball players with the highest percentage of fat - as pivot. Similar are the findings of Cavala et al. (2013).

High factor loadings on factor 4 have 2 variables – extroversion and tactical skills assessed by the coaches (with negative sign). This factor was named "*Introversion*" and expresses the tendency of coaches to lower their estimation of the tactical skills of extreme extroverts and to estimate higher players, who are less extroverted. Similar results are obtained by Zsheliaskova-Koynova & Bozhilov (2007) in a study on tactical decision making in volleyball: introverted volleyball players show higher results on decision making test and fluid intelligence test. In other studies researchers also found positive relationship between introversion and intelligence (Baker & Bichsel, 2006; Furnham, Forde & Cotter, 1998; Wolf & Ackerman, 2005).

Conclusions

Our findings show that the strongest influence on the physical and psychological qualities and technical and tactical skills of young female handball players has the psychophysical maturation during puberty. Players, who have reached a relatively advanced stage of maturation are characterized by a pronounced speed- and power qualities, better technical and tactical skills and higher emotional instability. Another factor that influences technical and tactical skills and physical attributes is the somatotype of girls. The lighter and faster players demonstrate better technical and tactical skills; at the same time the decisions in tactical situations and their technical implementation are relatively more difficult for the heavier and slower players. Achievement motivation influences decision making in tactical situations: players characterized by a strong drive to succeed, demonstrate better thinking than neurotic players characterized by a strong fear of failure. Finally, from more introverted players coaches could expect relatively better tactical skills than from extroverts.

Acceleration is a significant factor in the youth sport, but both accelerated players and girls with delayed maturation have their place in handball performing different functions in the game (specialization - of course, built on the basic universalization in order to favor the further development in sport). The same could be said about the somatotype – both lighter and heavier players have a chance for realization in handball, but in different positions. Coaches can expect greater speed and accuracy in execution of technical and tactical skills from lighter and faster players. The introverted players, although relatively unusual in handball, may also find their own niche when they are characterized by higher game intelligence. Coaches in collaboration with sports psychologists should put special efforts in order to cultivate hope for success and decrease fear of failure, in order to increase the quality of the players' tactical decision making. In particularly high risk to develop strong fear of failure are the emotionally unstable girls; this is the reason why coaches and sport psychologists should pay special attention to the development of their achievement motivation.

In conclusion, we would like to note that various aspects and features of the players never exist in fragmentation - they are always connected in an integrated wholeness. The identification of their relationships, of the ways they interconnect, of the different factors, taxons and types of players is a priority task for future studies in the field of handball.

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CONSTRUCTION OF AN OBSERVATIONAL SYSTEM FOR THE ORGANIZED ATTACK ON THE WOMEN'S HANDBALL: A CASE STUDY

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Summary
The aim of this study is to build an observational tool that permit to analyze the offensive process of a Women´s Handball Team. It were observed 9 games from Juventude Desportiva do Lis, 1st Division of the Portuguese Women National Championship, where were registered 521 offensive actions with change of ball possession. The results show the efficiency of the offensive actions, as well the overall of the games observed.

Keywords
Handball, game analysis, observation, offensive process, offensive actions, observation system.

Introduction
The analysis report about the opponent attack and the team itself is critical to the success of a team in Handball. They are distinguished from other types of games for the relevance technical-tactical factor (Gomes, 1998). The game observation, the game review or notational Analysis, are some of the expressions used to catalog the investigations about the game (Garganta, 1998). Sarmento (2004) stated that observation is an active and complex process. To observe it´s not just to look at what is happening around but capture different meanings through visualization. The observation can be directed to the choices but it may also be that the engagement is the "forward" targeting.

In Handball observation is always present, whether in training or in competition, and this will be more effective if combined with a good instrument for registration. To register it’s necessary to observe what is happening to then be able to take conclusions. This way, having a method of observation that can not only measure but also provide process offensive efficiencies, is something that will help in improving sporting performance, as well as the level of the training process. This study served to build an observation system for analyzing offensive game situations, analysis of results and the appropriate adjustment of the training process through the results obtained.

Methods
Participants and Measures
We filmed and observed 9 home games from Juventude Desportiva do Lis from the final phase of the 1st Division of the Portuguese Women National Championship, where we registered 521 offensive actions with change of ball possession.

The Videobserver is a tool that has been used for statistical analysis of games as well as for recording data. This tool has been applied mainly in handball but can be applied to other team sports. Through the recording of offensive actions it will be possible to represent the situation from the point of view of the observer for analysis and improvement of the training process. This tool has been prepared so that its use is accessible and allows the creation and correction of the observed categories, enabling the recording of events, their sequence and duration, subsequently giving numerous data on the observation made, including the videos created of the actions that were observed.

The process of recording data consumes some time and requires certain steps, namely:

1. Recording Game

All 9 home games were recorded by a digital camera in vob format and subsequent converted into mp4 format (a process that takes roughly 40 minutes per game through the program Handbrake©).

2. Load the game on the platform Videobserver

Already with the game in Mp4 format it was necessary to upload to the Videobserver platform.

3. Create a team on the platform

The creation process of the team Juve Lis, as well as the teams who played against in the final phase: Alavarium, Colégio de Gaia, Colégio João de Barros, Clube Andebol de Leça, Clube Sport Madeira, Escola Gil Eanes, Juventude e Amizade de Alcanena, Madeira Sad Andebol e Maiastar.

4. Create players of each team

We loaded information from athletes of all clubs through Digisource Company that runs the Videobsever and made the adjustments of the missing athletes including junior athletes who were not in the database.

5. Create the game on the platform

We created on the platform all games played by the Juventude Desportiva do Lis from the final phase of the 1st Division of the Portuguese Women National Championship during the season 2011-2012.

6. Add the video to the created game

All the games mentioned in the previous paragraph were added to the videos already created on the platform.

7. Analyzing process of the videos

During the observation of nine games we recorded all the actions that gave rise to completion or amendment that gave the ball. Therefore, all actions from Juve Lis who gave goal were recorded, the actions whenever the opponent won the ball and all those who had been finalized but originated new organization of the attack. Each record consisted of clicking the mouse at the beginning of a collective action, record the field location where the individual action occurred, record the action that occurred (if opponent had to register it as well) and finally put it back into collective action (end action) identifying it.

8. Analysis of tables

After the registration of all offensive actions and those who finished with change of possession were passed to Excel tables created in Videobserver referred to the effectiveness of the custom actions.

9. Sum of the actions of the nine games

In the Excel shhett we made all the sum, averages and efficacies (with and without free 7 meters) of all the actions of the games analyzed.

The analysis was based on the description of the actions that occurred in each game, and the sum of the actions of nine games observed. Averages, absolute frequencies and relative frequencies were used.

Thus, through the platform of Videobserver, we used the data tables per game and were analyzed taking into account the effectiveness, number of trials used in each class action, the number of goals scored on each action, failed attempts, as well as team errors. Subsequently we analyzed the values in the tables, taking into account the parameters previously defined: group actions, number of players, special situations and kind of defense. Finally we constituted table, taking into account the effectiveness of the group actions taking in account the 7m conquered.

The diversity of situations likely to be systematically observed behavior in sports, requires waive standardized instruments and instead devote the time needed to prepare them according to specific contexts (Prudente, Garganta, Anguera, 2004). The validity of the study was achieved by consulting three Handball Experts: two Phd in observation and analysis of the game of Handball (with experience as top coaches) and other high performance coach, undergraduate in Physical Education and Sport. The validation of the categories was made using three experts (undergraduation in physical education and top handball coaches - two of them with a Phd in Handball). The category system was presented to experts in order to conduct the internal validity which ultimately proves homogeneity, completeness, mutual exclusivity and relevance of the categories and parameters.

It's very important to refer that before being granted the consensus among observers for the categories, we designed a study design that has involved the following tasks: Learning and adjustment of the instrument of observation according to the aim of the study - Videobserver; Conducting various test matches during the 1st phase of the Women First Division National Championship; Construction of registration categories:

The validation was performed by categories of expertise, and the team of experts formed by Handball Teachers from other Universities, and technical level 4 (in training); After defining the categories and parameters that are in Word document, they were sent to the experts of the sport, which confirmed some of the other categories and set others; After the feedback and the recommendations from experts we made out the final document of the categories definition.

Parameters of Category **Action Group** in organized attack:
Given the expertise held by validation, the following parameters were defined for the category Action Game:
a) Entry point - action in which the player performs an entry point for the central zone of the 2nd row (pivot) with or without the ball;
b) Side entrance - action that perform side entrance to the central zone of the 2nd row (pivot) with or without the ball;
c) Centre input - action that perform a central entrance to the central zone of the 2nd row (pivot) with or without the ball;
d) Set outer pivot - pivot action that comes out of his position to receive the ball inside of one of their colleagues;
e) Exchange of specific post between 1st line - action where players of 1st line perform an exchange with each other in specific posts without the ball;
f) Exchange of specific post between 2nd line - action where players of 1st and 2nd line perform an exchange with each other in specific posts without the ball;
g) Exchange of position 1st and 2nd line - action where players of 1st and 2nd line perform an exchange between them of specific post without the ball;
h) Crossing 1st line - action where players from the 1st offensive line held, with ball, crossover (exchange of specific posts) from the front or the back;
i) Crosses between 1st and 2nd line - action where players of 1st and 2nd line offensive conduct among themselves and with the ball, a cross (exchange of specific posts) from the front or the back;
j) Two pivots - action where the team plays with two fixed pivots;
k) Input and output - input a player's 1st or 2nd line to the pivot position and subsequent output;
l) Attack Space - where the action team attacks the space setting each player their
Direct opponent making room for other colleagues;
m) Counter attack - if the team wins the ball and creates a situation of termination without giving the opposing team time to organize defensively;
n) Replacement quick - whenever the team after conceding a goal carries replacement fast ball in play (midfield) and try to create a situation of completion time without giving the opposing team is organized defensively.

Parameters of the category **Players**

Having regard to validation by carried expertise, the following parameters were set for the category Players

a) Superiority - when the offensive team in their process works with one or more elements compared to the defense, the number of players participating in the offensive, versus number of players who protect the goal (GK not included);

b) Inferiority - when the offensive team in the process operates under one or more elements compared to the defense, the number of players participating in the offensive, versus number of players who protect the goal (GK not included);

c) Equality - when the offensive team in the process operates with the same elements as compared to the defense, the number of players participating in the offensive versus number of players who protect the goal (GK not included).

Parameters of System **category defensive**

Having regard to validation by carried expertise, the following parameters are defined for category defense system:

a) 6:0 - 6 Players on one defensive line;

b) 5:1 - 5 players on 1st defensive line and the 2nd line;

c) 3:2:1 - Defense 3 defensive lines, 3 in 1, 2 in the 2nd and the 3rd one;

d) 5:0 - Five players on the defensive line;

e) 4:1 - Four players on 1st defensive line and one on the 2nd line;

f) 4:2 - Four players on 1st defensive line and 2 on the 2nd line;

g) Mixed - Part of the team defending zone and perform other individual marking;

h) Other - Any other kind of defense adopted;

i) Recovery defensive - when the team is in transition and defensively is not yet organized.

Parameters category **Special Situations**

Having regard to validation by carried expertise, the following parameters are defined for category Special Situations:

a) Passive Game - where collective action is carried out by the referee to indicate imminent passive game;

b) Free 9m - when the action takes place a free 9m;

c) Corners and throws - when the action arises out of a corner or;

d) Alley-oop - Action in which an athlete finishes getting the ball in the air;

e) Advanced Goalkeeper - when a team uses its GK in positional attack.

Custom Actions

To conduct the study were necessary collective actions of the team in accordance with the principles of game model set that took into account the individual characteristics and collective team, of Juventude Desportiva do Lis.

Cross 1 with change - exchange enters 1st and 2nd row, input tip to pivot and exchange between 1st line;

Cross 1 crossing- Switching between 1st and 2nd row, input tip to pivot and junction between the 1st line

Cross 2 with change - exchange enters 1st and 2nd row, input tip to pivot and exchange between 1st line;

Cross 2 with cross - exchange enters 1st and 2nd row, input tip to pivot and intersection between the 1st line;

E 1 - outdoor play pivot and input to central pivot;

E 2 - outdoor play pivot and lateral entry to pivot;

E 3 - Set outside of the pivot and input tip to pivot;

E change - outdoor play pivot and exchange between players of 1st line;
Inversion - exchange of players from 1st line;
Pole 1 - outdoor play pivot and input to central pivot
Pole 3- ; Outdoor play pivot and input wing to pivot;
Pole with exchange - Outdoor play pivot and exchange between 1st line;
C 1 - outdoor play pivot, intersection of 1st row with 2nd row, entry central pivot
C 2 - outdoor play pivot, intersection of 1st row with 2nd row, lateral entry pivot;
C with change - outdoor play pivot, intersection of 1st row with 2nd row, exchange between1st line;
Wing player 1 change - entry wing to pivot and exchange between 1st line;
Wing player 2 change - entry wing to pivot and exchange between 1st line;
Wing player 1 cross - entry wing to pivot and cross between 1st line
Wing player 2 cross - entry wing to pivot and cross between 1st line.
Double Backcourt - two intersections between the 1st line, crossing the Central Back and Side Back.

With regard to the **number of players** on the field and when the team plays in an unequal number, there are also collective actions already defined, namely:
Numerical superiority C - outdoor play pivot and exchange between 1st line;
Numerical superiority 2 - game with two fixed pivots
Numerical superiority fix - attack the space to fix the adversary
Numerical inferiority poste - entry wing, outdoor play pivot, switching between 1st line and cross between 1st line;
Numerical inferiority wing wing - entry point

With regard to **special situations** there are also some collective actions defined, namely:
Special situation GKA - status of completion made when using the Goalkeeper advanced to create equal or superior numbers;
Special situation alley-oop - situation held after completion of combination alley-oop;
Special situation Corners/throws - situation held after completion of a spare ball in play outside, throws or corner;
Special situation Passive play - situation finalization performed when indicated to the referee about to passive play;
Special situation free 9m - Collective action that arises from a situation of free 9m pre-defined and that results in a state of completion.

Regarding **Other parameters** are also defined some collective actions, including:
Defense mixed / Quick replacement / Fast-brake

Finally we created a category that could contemplate all situations finishing impossible to catalog in that instrument: Single / Other

Conclusions

Taking into account the work done, the first major conclusion is that without the validation of the observation would never be possible to conduct this study. In addition, after due consideration, some conclusions were drawn, namely:

Diversity of offense

Juve Lis has a wide range of actions, as 35 records were found. Seem to us too many actions to put in place, which hinders success, although some of these actions (custom) are applied in special situations (numerical inequality, mixed defenses, limit passive game, free 9m, against goal and counter attack).

Stocks slightly used

Juve Lis 27 shows actions that occur (on average) no more than 3 times a meeting, of which 24 were not more than twice.

Low effictively actions

Juve Lis has about 50% of the shares with efficiency lower than average overall offensive effectiveness, some of which have very low values.

Common actions

The counter-attack is the action most used by Juve Lis, seeking success, knowing that the 2nd most used action is individual / other (nonstandard action by team).

Actions more used in organized attack

Juve Lis most frequently used actions Individual / others (48 times), Inversion (32 times), Pole with change (26 times), Wing player 2 with change (24 times), C with change (24 times).

The actions include changing of 1st line are the most used actions by team. Juve Lis uses exchanges of 1st line as a means of tactical privileged group, when in positional attack.

High effectively actions

Juve Lis, within the 10 common actions only against the attack (48%) exceeds 40%.

Effectiveness of the actions above 40% with free 7m conquered

Juve Lis, within the 10 most used actions and accounting for the free 7m conquered, can values greater than 40% efficacy in several actions: Counter Attack (48%), C with change (54%), free 9m (44%) and Special Situation passive Play (45%).

Actions in numerical superiority

In situation of numerical superiority, the preferred Juve Lis was numerical superiority 2.

Actions in special situations

In this parameter, the special situation of free 9m and passive actions are used more by Juve Lis.

Free 7m Conquered

Juve Lis, observed in 9 games, managed to win 34 free 7m.

Actions in special situations

In this parameter, the special situation of free 9m and passive actions are used more by Juve Lis.

Sequence of actions

Regarding the sequence of actions to highlight the most used: Game outer pivot followed by exchange of the 1st line entry point to return the 1st row and entry point to the intersection of 1st line.

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THE GOALKEEPER'S EFFECTIVENESS IN THE SEVEN-METER THROW

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Summary
To investigate the factors that affects the goalkeeper efficiency when facing seven-meter free throws. The overall efficiency of 24% increases to 27% when playing as visitors. It is spatially dependent and is lower to bounced shots (30%) than to direct shots (69%). This means that the goalkeepers training can be directed to strengthen some of these weak areas.

Keywords
Handball, seven-meter, goalkeeper, efficiency

Introduction
The performance evaluation from individual handball athletes up to the whole team is an important task in the training and competition planning process (Taborsky, 2011). Handball in many tasks allows a binary evaluation - *goal* or *no goal* – simplifying the definition of performance by means of success ratios (Foretić et al. 2011).

The effectiveness of the goalkeeper in all phases of the game, as well as the knowledge of all the variables that influence it, have been gaining increased impact in team performance (Kovacs, 2009). Today the goalkeeper is both the last defender and the first attacker, consequence (and cause) of game evolution: a faster game with quick ball replacements, fast-breaks, etc.

The seven-meter free throw is executed in a specific context, where the two opponents – shooter and goalkeeper - are in a face-to-face static situation with no external interference. In this asymmetric duel, the thrower has a much higher probability of success. Training for this situation is frequently focused on improving perception and decision-making (Fuertes, 2006). These decisions are, however, anticipatory and speculative in nature due to the very short time available for reacting to the shots. So, statistical data on the details of the seven-meter throw can aid with the anticipation and movement analysis of the opponents (Medina, Villanueva, Nicolas and Parra, 2004).

Methods
Sample
All the 460 seven-meter penalties occurred in a sample of 57 of the set of 66 matches in the first round/first phase of the 2012/2013 Portuguese Handball National Championship (adults first division). The remaining 9 matches had no video records of enough quality for these purposes.

Procedures
The video records obtained during the matches where combined with zoom, slow motion and, when necessary, the aid of an expert. These where the main data sources. Match reports were also available and consulted as needed.

Variables collected at the time of each seven-meter penalty were: playing time, thrower ID, thrower team, teams' score, goalkeeper ID, goalkeeper team, goalkeeper initial position (distance to the goal line), type of shot, target goal zone, result, condition home/away, executing arm of the shot, deception strategies of thrower, thrower was previously infield or at reserve box, goalkeeper was previously infield or at reserve box.

The target goal zone was evaluated in the moment that the ball crossed the goalkeeper plane. The *zones* are defined in figure 1, relative to a goalkeeper in standard position: to the right of the right arm (1), between the arms (2), to the left of the left arm (3), between the right shoulder and the right side of the hip (4), between the left shoulder and the left side of the hip (5), between the right side of the hip and the floor (6), between the legs (7), between the left side of the hip and the floor (8).

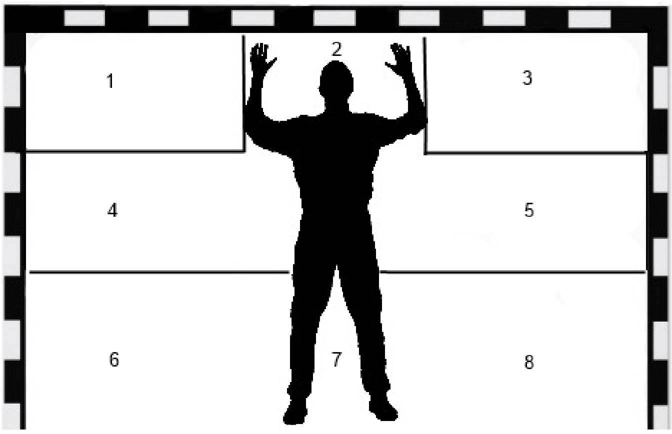

Figure 1 – *Target goal zones*

Statistical Analysis
Simple descriptive (means, ratios, etc.) and inferential (t-test) techniques were used.

Exclusion criteria
All matches in which there was a (partial or total) absence of video records were excluded. Those where the official match report was unavailable were also excluded.

Development (results and discussion)
The analyzed sample of the 2012/2013 Portuguese top Handball Championship showed an average of 8 seven-meter penalties per match. For comparison, in the 2013 World Championship (held at Spain) the average was 4 events per match. This underlines the importance of this theme in national (at least Portuguese) competitions.

Regarding the type of shot, most shooters prefer direct shots (69%) over bounced shots (30%), as can be seen in table 1. However the effectiveness of bounced shots (83%) is significantly superior ($p<0.006\%$) to the direct ones (73%) - see figure 1.

Table 1 – *Results of shots at goal*

Type of Shot	goal	stopped by GK	crossbar/posts	out	Total
Direct	232	66	14	7	319
Bounced	114	10	7	6	137
Lob	3	0	1	0	4

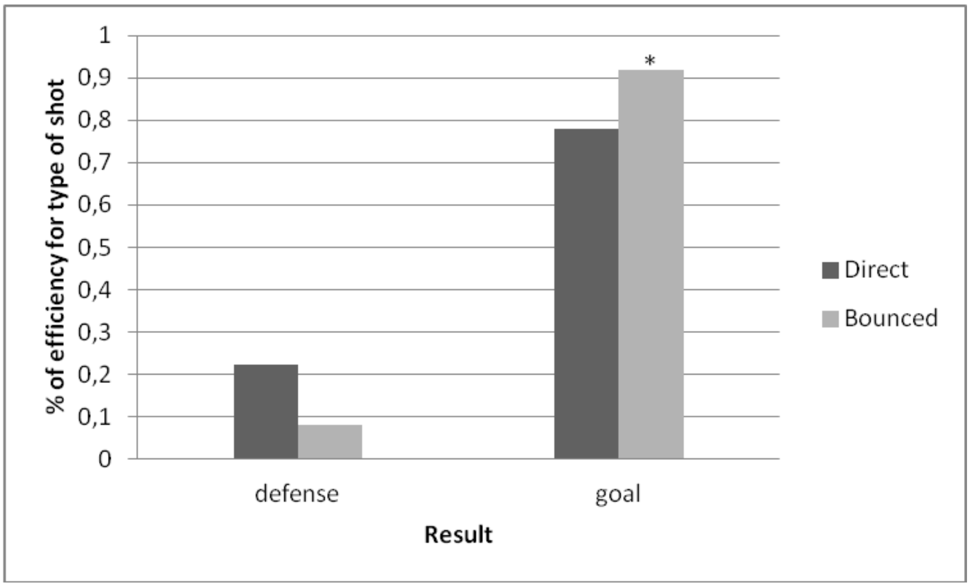

Figure 2 - *Efficiency for type of shot (*statistically significant)*

The goalkeeper efficiency (24.1%) was in line with other tournaments, e.g. 29% in the World Championship (Foretić et al., 2011) or 19% in the Spanish Liga Asobal 2008/2009 (Casimiro, 2010).

Goalkeeper efficiency is spatial dependent, as can be seen in figure 3.

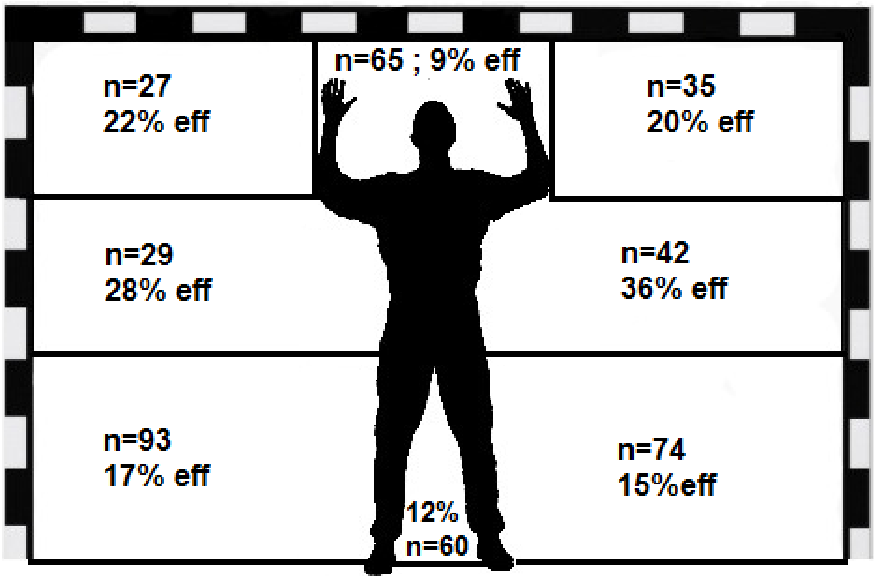

Figure 3 – *Number of shots to each goal area and goalkeeper defensive efficiency*

Playing as visitors, goalkeepers show an increased efficiency of 26.9% efficient than when playing at the home condition (21.5%, p<1.5%), figure 2. In the Liga Asobal 2008/2009 there were no significant differences (Casimiro, 2010). Common knowledge emphasizes spectators' manifestation, familiarity with the place of the game, displacements and the interaction between these factors as strong influencers (Pollard, 2008; Page and Page, 2007).

Unfortunately these influences explain only a stronger *home* performance. We suspect that it is the responsibility and stress over the shooter that explains these results.

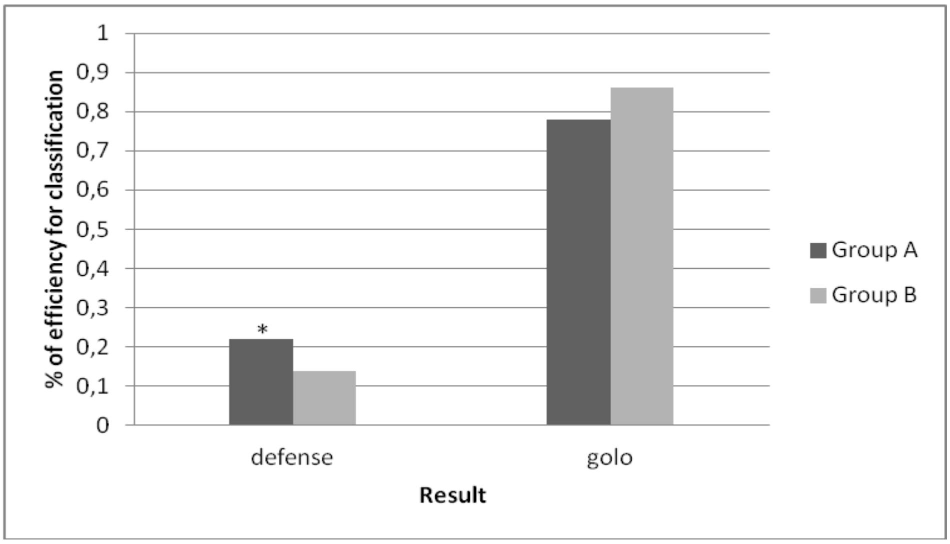

Figure 4 - *Efficiency by place of match (*statistically significant)*

The teams that qualified for the final phase in the A group (the best teams) have goalkeepers more efficient in defending seven-meter penalties (8 percentual points higher) than those playing in teams that qualified only for the B group (p<2.8%), figure 3. This can be seen both as a cause and a consequence – the best team hire the best goalkeepers and the best goalkeepers help the teams to qualify higher. This is line with the London 2012 Olympic Games, where the teams in the top 6 places had an average efficiency of 32.3% on the opposition to the seven-meter penalties, while the six worst teams had only 19,8% (WHF, 2013). In the Liga Asobal, no difference was observed (Casimiro, 2010).

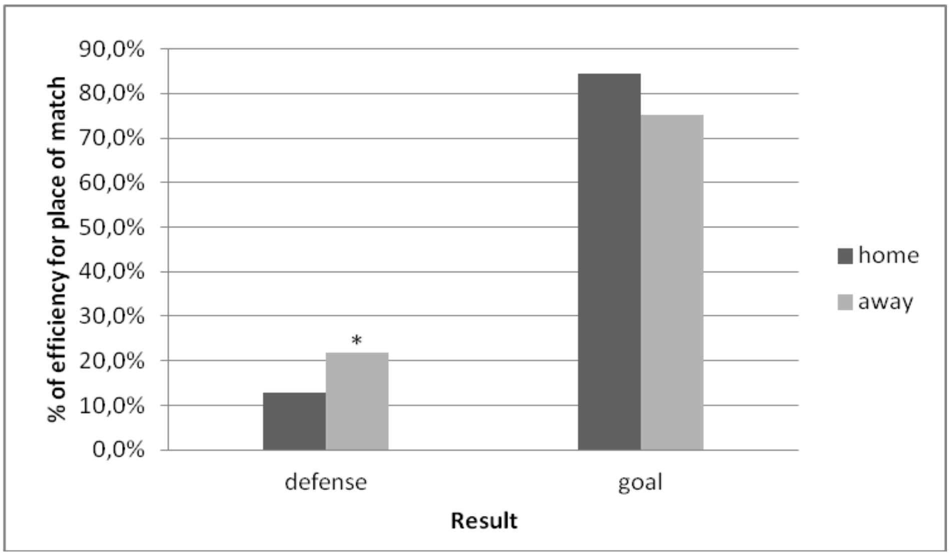

Figure 5 – *Goalkeeper efficiency by team performance (*statistically significant)*

Conclusions

Overall, goalkeepers oppose successfully to on 25% of all seven-meter penalties. However this efficiency is higher when playing as visitors and lower when playing at home. This is surprising and needs further analysis.

Bounced shots are rarely used but are more effective than direct shots. This may suggest the need for special training attention.

- There is a strong association between teams' performance and goalkeepers' performance.
- This is not totally unexpected.
- This type of analysis is now being expanded to include other aspects of playing and other players.

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TRACKING MULTIPLE HANDBALL PLAYERS USING MULTI-COMMODITY NETWORK FLOW FOR ASSESSING TACTICAL BEHAVIOUR

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Summary
The aim of this work is to present an approach that can help to characterize teams' and players' tactical behavior using two techniques to aid handball coaches to assess tactical procedures when using spatial measures derived from players position data. Results suggest that it is possible to identify tactical spatial differences between fast-break and fast throw-off. The approach presented in this work may be useful to reduce the time spent in game analysis and to improve coaches' assessment of tactical performance during the training sessions.

Keywords
Handball, tracking multiple players, spatial measures, Voronoi diagrams, tactical assessment.

Introduction
Handball is a professional team sport to which little scientific investigation has been dedicated, regarding tactical performance analysis, despite the growing interest of many research areas on studying players' behavior and teams' dynamics (Emmerik REA Van, 2004; Glazier P., et al., 2003). Unlike recent studies in other team sports, such as soccer (Bartlett R., et al., 2012) and basketball (Bourbousson J., et al., 2012), where modern and innovative approaches are considered, in handball, and to the best of our knowledge, most of the research studies consider a descriptive analysis of the game (Hughes M, Franks I., 2004). Commonly, a notational data analysis (Hughes M, Bartlett R., 2002) is performed and a set of categories is considered to classify the observed actions of the players during the game, being this particularly focused on the player with the ball (e.g., where he/she is in the field, to whom he/she passes the ball, where in the goal he/she shots the ball), disregarding other sources of information that may influence the course of the action, such as the position of the teammates and opponents as well the tactical context of the play. Despite limitations of this kind of analysis for assessing teams' and players' performance, these categories are still used (Meletakos P., et al, 2011; Rogulj N., et al., 2011) and regarded as reliable indicators for handball experts' performance analysts (e.g. EHF Periodical- Pokrajac B.).

With the advances of technologies, there are now a number of systems that allow capturing other types of data (Leser R., et al., 2011) from matches or training sessions. In particular, positional data can be made available for academic research purposes by means of, for example, Ubisense tracking system (Leser R., et al., 2011), which allow a different approach for analyzing teams' and players' performance. The analysis of positional data has been recognized as a promising way to study in depth performance in team sports (Glazier P., et al., 2003; Reed D, Hughes M., 2006), and many authors have already considered these data for theoretical approaches in a few sports, such as basketball (Bourbousson J., et al., 2012), football (Headrick J., et al., 2012), futsal (Travassos B., et al. 2010) and rugby (Passos P., et al. 2010). Although these studies have demonstrated the potential of this analysis in assessing teams' and players' performance, the scientific nature of the whole work do not allow a clear understanding of the game by the sports agents of interest, mainly coaches. Thus, a more

practical approach is required when considering these powerful data, which is an essential tool for, not only acquiring team sports' performance, but also identifying well-known game principles (Lopes A., et al., 2013).
This exploratory research presents a preliminary summary of two novel techniques applied to handball in order to help coaches assess tactical procedures in training sessions: (1) a multi-commodity network flow to track multiple handball players and collect players' trajectories and, (2) a spatial approach for analyzing players' positional data and describing the interaction behavior of attack and defense teams when considering different transition tactics, fast-break and fast throw-off.

Methods
Study design
A mixed method study design (Camerino O., et al., 2012) has been used considering both qualitative (classification of the sequences in two categories using observational methodology (Teresa M., et al., 2011): fast-break and fast throw-off) and quantitative data (positional data from each player).

Sample
In a training session of the Portuguese women's handball national team, an exercise of attack transition after goal was recorded. The exercise was played during 15 minutes in half court (20m×20m) in a 6×6+GK situation. At the signal of the coach, players would perform one of two types of transition – fast-break or fast throw-off. During the whole session, players' position was tracked using the registry of only one video camera, as described below. A sequence of each type of transition was considered for this study.

Tracking system
The ground floor of the handball court was represented as a grid of cells with a resolution of 20cm×20cm. The goal of the system is to estimate, at each frame, which grid cells are occupied and by whom. The system is composed of three core components: detection, identification and tracking. Detection is based on a generative model which can effectively handle occlusions in each time frame independently. This produces a Probability Occupancy Map (POM). The detection algorithm is developed for multiple people detection from multiple cameras (Fleuret F., et al., 2012) and also applicable for a single camera as well (Ben Shitrit H., et al., 2013). The detected location of the people are then used by the next components of the tracking system. The identification component recognizes the identity of the person according to his color histogram, facial descriptor and his/her jersey number. In our case, we used only the shirt colors in order to distinguish between the role of the players (attack and defense). In the final tracking component, the multi-people tracking problem is formulated as a multi-commodity network flow problem (Shitrit H. Ben, et al., 2011; Ben Shitrit H., et al., 2013). The tracker links the detections of people in individual frames across time, while taking into account the appearance and identity constraints, obtaining the players' trajectory movement.

Spatial assessment
Players' positional data collected on both sequences (sequence 1: fast-break and sequence 2: fast throw-off) were considered to calculate spatial metrics to describe the behavior of attack and defense teams, namely, the area of the convex-hull, the area of the bounding rectangle (Lopes A., et al., 2013) and the Voronoi area (Kim S., 2004), all reported in % relative to the field area and calculated using routines implemented in Matlab R2008a software. These represent the % of covered area by each team.

Results and Discussion

The aim of this exploratory study was to apply a novel tracking system to gather positional data from handball players during a training exercise of transition (fast-break and fast throw-off) and to characterize teams' tactical behavior by means of spatial metrics derived from their trajectories.

Next are presented each of the metrics mentioned above calculated for each team and for each sequence. Note that the first sequence was a fast break (sequence 1) that involved several attacking players, all of them starting the sequence in the center of the court except for both wing players that were already set in specific positions; the second sequence corresponded to a fast throw-off (sequence 2), also involving several attacking players, but in this case all players, including the wingers, started the sequence behind the midfield line. In both sequences, the defender players are in position using a 6:0 defense system. The figures below describe the evolution of the % of covered area, assessed by different spatial measures, across the duration of each sequence, for the attack and defense teams, in grey and black solid lines, respectively.

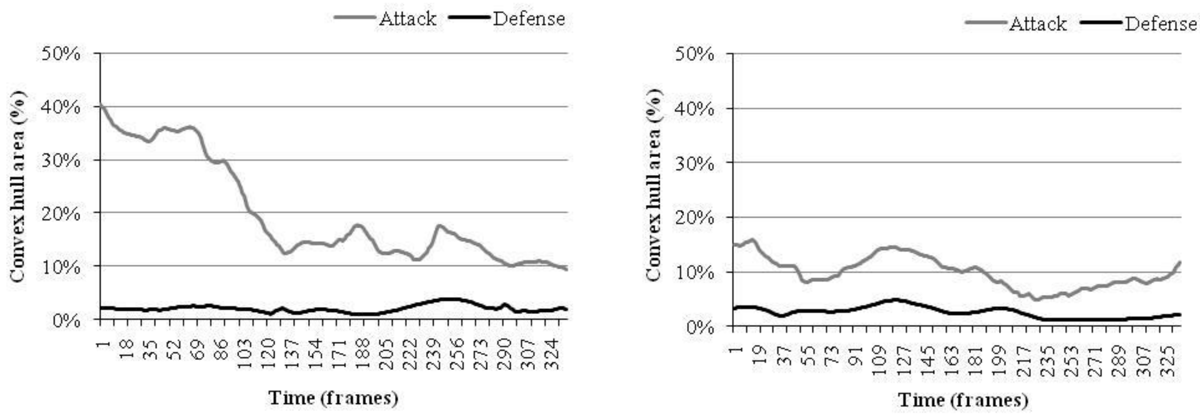

Figure 1: *Convex-hull area (in percentage of field area) calculated for the attack and defense teams in sequence 1: fast break (left) and sequence 2: fast throw-off (right)*

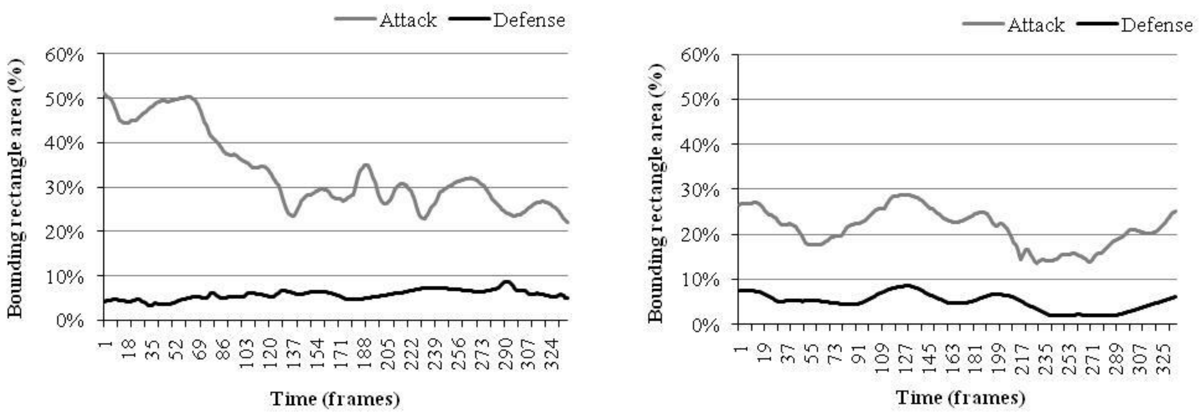

Figure 2. *Bounding rectangle (in percentage of field area) calculated for the attack and defense teams in sequence 1: fast break (left) and sequence 2: fast throw-off (right)*

When considering the convex-hull and bounding rectangle areas, in Figure 1 and Figure 2, respectively, it is clear that the % of covered area of the defending team is, across the whole time and for both sequences, lower than the attacking team, being this in accordance with game principles. In addition, the % of covered area for the attack tends to decrease as they get closer to the defenders, presenting more and higher fluctuations in comparison with the defense team. This might have to do with the use of the 2nd pivot or the changes or combinations between backcourt players and the pivots, with the defense team trying to maintain their defense system with the same structure. Regarding the difference between the two types of transition (fast break vs. fast thow-off), it is clear that in the beginning of sequence 1 (fast break), the attacking team covers more space, as the wingers are further from the other teammates. But, in the course of the sequence, this distance decreases and, consequently, the area occupied by the attack also decreases. In sequence 2 (fast throw-off), the % of covered area for the attack is, across the whole time, considerably smaller, as the players progress in the field, exploring it more in width than in depth.

Although both of these measures give relevant information about the evolution of the % of area occupied for each team and are able to capture the differences between the two modes of transition after goal, they present some of the same limitations previously identified in other team sports (Lopes A., et al., 2013; McGarry T., 2009; Fonseca S., et al., 2013), in particular, the dimensions of the playing area and the possibility of having teams' convex-hull/bounding rectangle overlapped are disregarded. Since the Voronoi diagram approach appears to overcome these specific limitations, it was also considered here (Figure 3, below). This spatial tessellation considers the playing area (excluding restricted areas as the GK area in this particular sport) and divides it into cells, each "owned" by one and only one player, here designated Voronoi area (VA). The % of covered area (%VA) for each team is the sum of the area of the cells associated to the respective players.

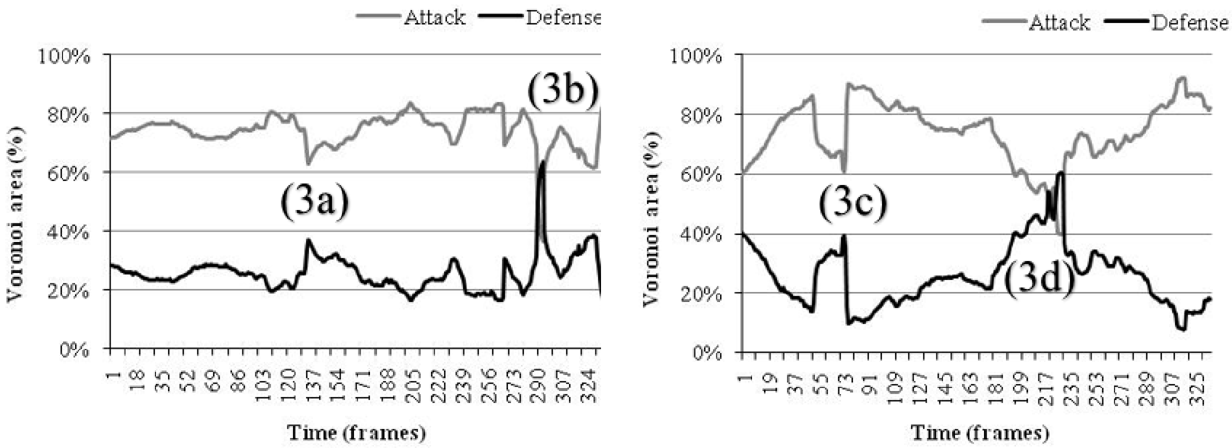

Figure 3. *Voronoi diagram (in percentage of field area) calculated for the attack and defense teams in sequence 1: fast break (left) and sequence 2: fast throw-off (right)*

In opposition to what was observed in the previous spatial measures, the Voronoi area occupied by both teams represents the whole playing area, according to definition of the spatial model itself. Consequently, the increase of the area by one team implies a decrease of the area of the other. Similarly to the previous metrics, the attack team covers more area than the defense team, but unlike those, this is not maintained through the whole sequence. With this approach it is possible to identify moments when the space dominance is somehow balanced (~50% each team) and moments when a sudden dominance of the defense team is observed. These sort of variations seem to be associated with specific collective and individual actions that aim to disrupt the shape and organization of the defense system (Figure

3): (a) the attacking makes the pivot come out from the inside of the defense or makes it cross, and a defender goes out with her until the delivery to a teammate; (b) this type of perturbation reveals that the attacking team went inside the defense in penetration (using or not a two pivot displacement, trying to attract the defenders to outside their zone) and tried to score, and did not make it through, but then again they still maintain the ball possession until the end of the sequence where they attempt to score; (c) the defense team tries to anticipate them attacking movement and this latter team spread out around the field in width and in depth to break the defense team in two parts, and then strengthening the attack in depth; (d) give origin to 2×2 and 1×1 combinations inside the 9m with the defending team trying to intercept the ball.

Conclusions

Handball is a team sports characterized by a fast intertwined and dynamic interactions between players, and a deeper understanding of this complex dynamic spatial interaction is required in order to serve the interests of both academic and sports agents. In this paper, three spatial metrics are presented with the aim of addressing the above problem. From the results of this experimental study, where an actual handball exercise was considered, it was found that the %VA could be used to quantitatively and qualitative describe the tactical behavior of the two teams in two distinct types of transition. This exploratory work is small yet, but the results are pointing towards the right direction, i.e., the analysis matches what coaches recognize as relevant to describe and identify tactical concepts in handball. Still, and although the Voronoi approach overcomes some limitations of other spatial measures, it presents other limitations that might be overcome using some suggestions in the work developed by Taki, and Hasegawa (Taki T., Hasegawa J., 2000) in order to capture more of the functional and dynamical behavior of each player and team during performance.

Acknowledgements

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AN EXAMPLE OF TRANSFER CHARACTERISTICS IN THE WOMEN'S EHF CHAMPIONS LEAGUE DURING THE SEASON 2012/13: THE NATIONALITY PERSPECTIVE

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Summary
In this study, eight best ranked clubs in the main round of the Women's EHF Champions League in 2012/13 season - in terms of player's nationality and players transfers were analysed.

The results of the study showed that countries with long handball traditions and successful national teams have a smaller amount of foreign players in their professional club teams; but at the same time, such countries play an important role in European women's handball in general.

Keywords
Women handball, nationality, transfer, champion's league, migration

Introduction
The global migrations of athletic workers have increased dramatically in magnitude, composition, and direction in recent years. Studies examining these migrations have, however, remained limited to specific areas and have restricted their vision to those workers employed in the athletic sector. Few studies have drawn on concepts derived from research tracing the migrations of workers in other areas: the highly skilled, for example. Study (Eliot, Maguire. (2008) shows how an understanding of athletic labour migration could be extended by drawing on research from the area of highly skilled labour migration.

The migrations of athletes have become a prominent feature of global sports worlds (Maguire, 1999; Maguire, Jarvie, Mansfeld, & Bradley, 2002). In many sports, athletes are migrating within nation states, between nation states on the same continent, and beyond their own continents. The result is a contemporary sporting culture whereby athletic labor fows increasingly traverse geographical, political, cultural, ethnic, and economic boundaries.

Models of migrations in sport are not uniform but vary with respect to the particular sport discipline, an athlete's gender, country and continent. According to Swinnen and Vandemoortele (2008), migration paths in ice hockey run from Eastern Europe to the USA and Canada, while in basketball from Europe and South America to the USA. North American athletes who are not successful in their own leagues transfer to Europe. In Danish women's handball, migrations from Northern and Eastern Europe prevail (Agergaard, 2008). According to Doupona Topič and Bon (2008), Germany is the leading country of handball migrations in Western Europe, while in Eastern Europe most players migrate from Romania. In the 1990s the 'Bosman ruling' significantly influenced the globalisation of professional football in Europe. Before the Bosman ruling came into effect (before 1996), UEFA's restriction was limited to three foreign players per match. Since the Bosman case in 1995, footballers from the European Union no longer have the status of a foreigner when playing in other EU countries. This led to an increase of sport migrations in Europe.

According to Maguire (1996), sports migrants fall into five categories: pioneers, settlers, mercenaries, returnees, and nomadic cosmopolitans. Magee and Sugden (2002) added two categories to the typology as a result of their qualitative study on foreign football players in England. An analysis of interviews with players showed that migrants in sport can be characterised as mercenaries (migration is economically motivated), settlers (athletes stay in a country for four to five years, many even remain after they retire from sport), careerists (migration due to sports career interests), nomadic cosmopolitans (a desire to experience other cultures), exiles (athletes leave their home country for personal or political reasons), and stars (migration is motivated by media popularity).

Migration occurs on a number of levels and for several reasons. In handball migration or transfers are in increasing. Doupona, Bon (2007) made a large study where is found up, that in period from 1996 till 2006 male handball players have transferred more times than female players. Namely, the number of transfers of male players amounted to 5.433 (60,1% of all transfers), whereas the number of transfers of female players was 3.602 (39,9% of all transfers). The proportion of transfers according to gender is nearly equal in Western and Scandinavian countries. The biggest difference in the proportion of transfers between the genders is in former Yugoslav countries, where over two thirds of all transfers are transfers of the male players (29,6% - women compared to 70,4% - men) (Doupona, Bon, 2008) .

In this article we seek to revisit research that has been conducted in the sociology of sport in an attempt to set out what understanding has been generated in the area this far. More importantly, however, we use this article to analyse the transfers (migration) in the Women's EHF Champions League in 2012/13 season.

Method

All data were obtained from the European Handball Federation (EHF), which assumes the responsibility for all transfer contracts of players within Europe in accordance with the International Handball Federations' (IHF) "Player Eligibility Code" and the "IHF Regulations for Transfer between Federations". The data include transfer characteristics (start and finish release, country from and country to) and some socio-demographical characteristics.

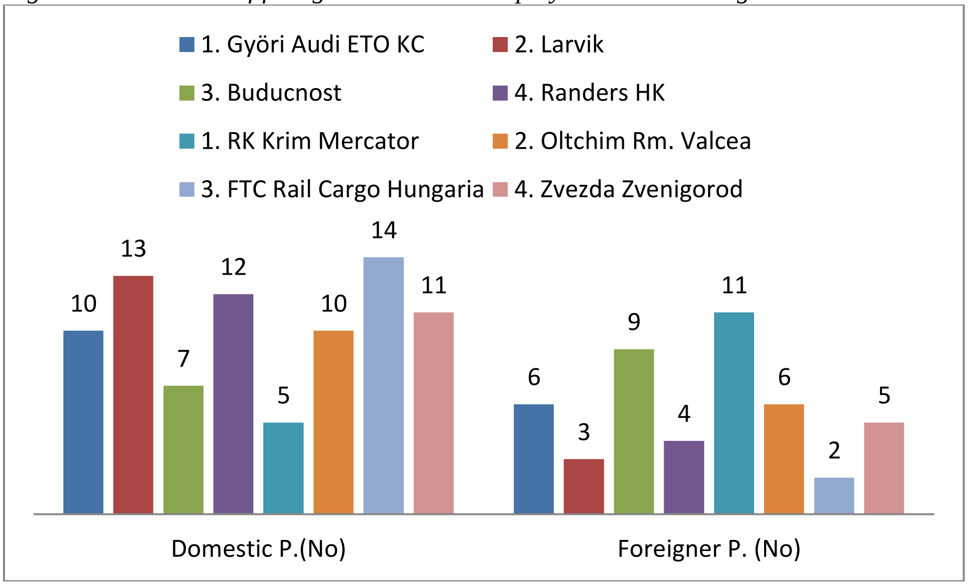
Results

Results show that the top eight clubs in season 2012/13 (Győri Audi ETO KC - Hungary; Larvik – Norway; Oltchim Rm. Valcea - Romania; Krim – Slovenia; Buducnost - Montenegro; Randers HK - Denmark; FTC Rail Cargo Hungaria – Hungary; and Zvezda Zvenigorod – Russia), registered 168 female handball players during the season and 4 players did leave clubs. Altogether, among the 168 players, 17 different nationalities were recorded; players from 15 countries were listed as foreign players; and only players from Slovenia (SLO) and Romania (ROU) were treated as domestic players. No Romanian player was in other teams as foreigner, and the same is valued for Slovenian players.

Table 1: An overview of nationality structure of eight best teams in Champions league in seasons 2012/13

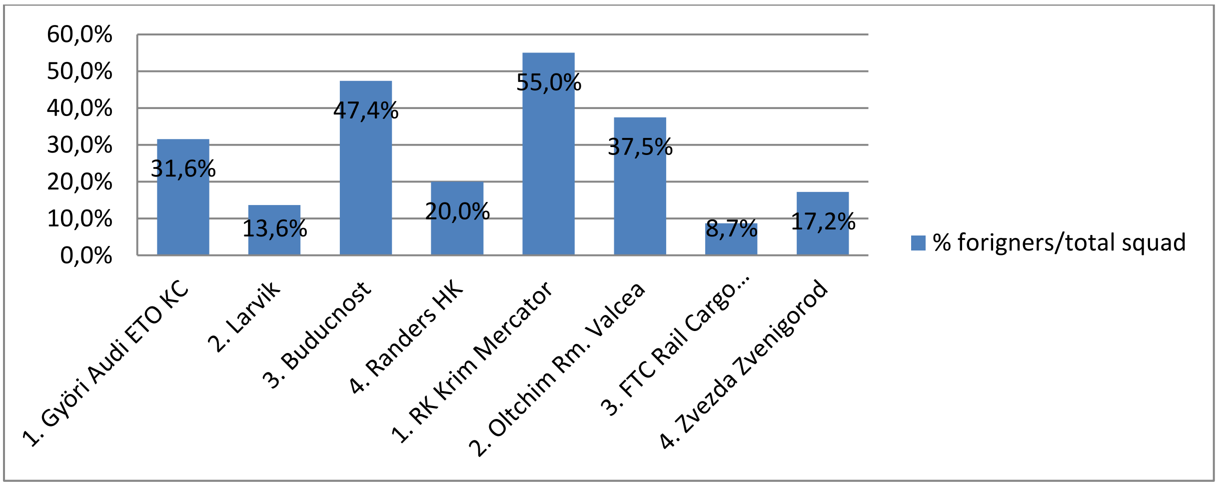
COUNTRY	TEAM (16 PLAYERS)	% Foreigner Players	Domestic Players (No)	Foreigner Players (No)
HUN	**1. Györi Audi ETO KC**	37,5%	10	6
NOR	**2. Larvik**	18,8%	13	3
MNE	**3. Buducnost**	56,3%	7	9
DEN	**4. Randers HK**	25,0%	12	4
SLO	**1. RK Krim Mercator**	68,8%	5	11
ROU	**2. Oltchim Rm. Valcea**	37,5%	10	6
HUN	**3. FTC Rail Cargo Hungaria**	12,5%	14	2
RUS	**4. Zvezda Zvenigorod**	31,3%	11	**5**
35,9%	**82**	**46**		

Figure 1: An amount of foreigner and domestic players in the best eight teams



From the 168 registered players, 46 (27.4%) players were sport migrants; it means that they played for foreign club. When looking only at the core official squad (16 players) we can say that on average 35.9% players are sport migrants. Out of 46 foreigner players, 27 (58.7%) were from non-EU members states; and 19 (41.3%) came from EU member states. From the nationality perspective in the main round, most players were from Hungary (Σ=35; 20.8%) followed by Russia (Σ=25; 15.5%) and subsequently, Norway (Σ=21; 12.5%). On a national team level, these countries have nearly always ranked at the top. The most extreme situation was found at the club Krim in Slovenia. The club hired 11 foreign players who belonged to eight different nationalities. This gave a recorded value of 68.8% foreign players in the team. At the club team Krim there are only five native Slovenian players who, except two of them, play a marginal role.

Figure 2: Foreigner players in the best eight teams in %



Conclusion

One of the consequences of the increasingly global nature of athletic migration is that patterns of athletic labour flow between host and donor countries can be more easily identified. The movement of athletic labour from a donor to a host country varies depending on the sport. In some sports, however, movement in a targeted and specific manner is increasingly facilitated through a series of “talent pipelines” (Maguire et al., 2002).

This study is part of broader research of the migration paths in handball. In this study, eight best ranked clubs in the main round of the Women's EHF Champions League in 2012/13 season - in terms of player's nationality and connected transfers - were analysed.

In the paper we analysed the national structure of all eight teams and distinguish similarities as well as differences between clubs and countries. Furthermore, we tried to stress the impact that increasingly frequent migration has on handball teams and on the quality of the teams in each country.

The results of the study showed that countries with long handball traditions and successful national teams (NOR, DEN, HUN) have a smaller amount of foreign players in their professional club teams; and at the same time, such countries play an important role in European women's handball in general.

Sport has in recent years, and with the assistance of the global media, become especially important in the formation of national identities that have little support in long term national traditions, rituals, and official history (Billig, 1995; Edensor, 2002) It seems that this is a case also when we speak about the most successful handball teams. To establish and strengthen team as well as national identity, it is necessary foster linkages between highly recognized symbols and rituals on the one hand, and the collective decisions, laws, and actions of the nation-state. Symbols express values and enable people to express, share, and reaffirm their membership in a collectivity. Although a national flag and coat-of-arms constitute such symbols, they are not as effective as individuals and concrete activities and events that embody a sense of nationhood with which people can identify as they are incorporated into popular discourse and culture.

This study suggests that sports play an important role also in creating and maintaining national identity.

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RULING AND REALITY – THE HANDBALL CASE

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Summary
To quantify the accuracy of the Portuguese elite Handball referees and of the accredited examiners. Results: in 9 matches, 1476 refereeing decisions were made, 98 of which were considered incorrect and in other 97 cases faults were not sanctioned. Curiously in 26% of all errors experts (with unlimited time and video replays) do not reach a consensus about what would be a correct decision.

Introduction
Referees are responsible for ensuring that the rules are fairly and impartially applied and that players remain safe. In handball, like in many other team sports, the referees are submitted to a huge pressure as their decisions may influence the final result of matches and competitions. Frequently the referees are criticized as inconsistent and biased. These accusations seem more frequent among the losing teams and so a more impartial and objective analysis on the quality of refereeing is needed. Few studies have produced evidences to support the *bias* assumption (Estriga et al., 2011) and the majority focuses mainly on the factors affecting the referees' judgment (e.g., Jones et al., 2002; Nevill and Holder, 1999; Nevill, Balmer, and William, 2002; Trudel et al. 2002).

Aware of this problem the official bodies have established mechanisms for referee classification, promotion and selection. Additionally some federations have developed education programs to improve referees and their general ruling quality. In tight cooperation with the Portuguese Handball Federation and the Refereeing Commission, the authors developed this study to quantify the ruling quality and also evaluate the consistency of the accredited *match examiners*.

Methods
Sample
Ten elite Portuguese handball referees and four highly experienced official *match examiners* (all EHF oficials, 1 not Portuguese) were involved in this study. Data was collected during the final phase of the Portuguese Men Supertaça (2011) - a set of 9 matches between 6 teams in 3 days on a neutral court.

Procedures
Match recording
Each match was recorded by three HD cameras (1920x1080@25fps) from elevated positions. Two were providing detailed close views of the action near the goals and a third one was located at middle court to get a wide-angle view. At each game all four examiners were simultaneously but independently at work (filling the official evaluation forms) while their notes and audio comments were recorded synchronously with the videos recording the match.
All obtained videos from the different perspectives were time synchronized. This allowed the researchers to easily find and view different perspectives of the same match scene.

Figure 1. *Three HD video cameras were used - one near each goal and one at middle court, all at elevated positions*

Figure 2. *Examiners: record live commentaries*

Immediately after matches, all the records were analyzed by two of the researchers who produced small video sequences (with multiple angle views, zoom and slow motion when needed) containing all the suspect ruling situations and all the doubtful absence of intervention situations, as noted by the match examiners. Included were also all other scenes of decisions the researchers deemed wrong or missing. Afterwards, examiners and referees reviewed individually all these sequences and their judgments were registered. Finally the correctness of each ruling decision was determined based on majority criteria or, on the lack of it, the original live decisions were considered correct.

A special class of errors was created – the *serious* errors – to consider errors that could affect the score: errors about 7m penalties, 2’’ suspensions, red cards, goals.

Development (results and discussion)

The main results are in tables 1 to 3. Several interesting conclusions can be drawn from them.

There is an average of 13% errors in a match and 5% *serious* errors. The average serious errors distribute evenly among the teams so, on average, they do not influence the outcome of a match. But in some cases they do. The majority (50%) of all errors and of the *serious* errors are caused by missing to sanction existing faults.

The number of non consensual offline decisions is bigger than the number of errors, meaning that in some cases the confirmation of the live ruling was done by a simple majority.

In the case of *serious* errors the number of non consensual offline decisions is slightly smaller than the number of errors. But sometimes there is no consensus even among the referees (one can say it was a fault for a 2’’ suspension and the other says that it was no fault at all).

The last two paragraphs show the difficulty of some decisions than cannot be overcome by increased training, technological aids or more in-court referees. This panel of 7 highly experienced persons unrelated to any teams, after seeing the live match in loco and reviewing it later with unlimited time and almost unlimited technical aids cannot reach a consensus in most of the *serious* errors.

Table 1. *Decomposition of Total Errors*

Total ruling actions	Total errors	Sanctioned non existing fault	Applied wrong or contrary sanction	Did not sanctioned existing fault
164.0	21.7	2.7	8.2	10.8

Table 2. *Decomposition of Serious Errors*

Total ruling actions	Total *serious* errors	Sanctioned as *serious* a non *serious* faults	Applied wrong or contrary *serious* sanction	Downgraded a *serious* fault	Did not sanctioned existing *serious* fault
164.0	8.3	1.7	0.6	2.0	4.1

Table 3. *Average of non consensual analysis of selected reviewed ruling situation*

Not consensual about all errors	Not consensual about *serious* errors
30	6.7

We also analyzed the spatial and temporal distribution of faults (Figure 3). The majority of faults occurred during the defensive phase and very few were reported to the offensive or offensive transitions phases (**Fehler! Verweisquelle konnte nicht gefunden werden.**). The faults typically were committed in the middle positions (including circle running, middle and middle back left and right positions). Following this tendency the majority of the ruling errors are also reported to this field zones.

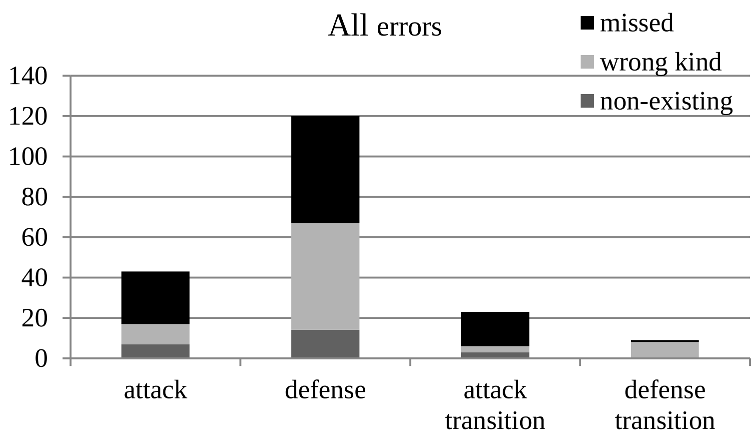
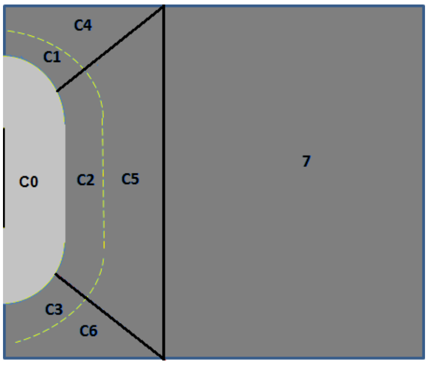


Figure 3. *The distribution of errors per game phase*



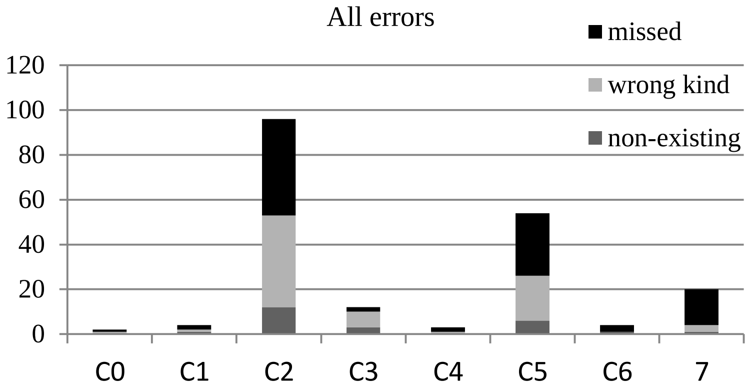


Figure 4. *Defined field zones*

Figure 5. *The distribution of errors relative to field zones.*

In previous studies we found a smooth tendency for increasing the number of ruling mistakes in the beginning and ending of matches (Estriga et al., 2011). In this work we were able only to find this tendency in the begging of the matches (Figure 6).

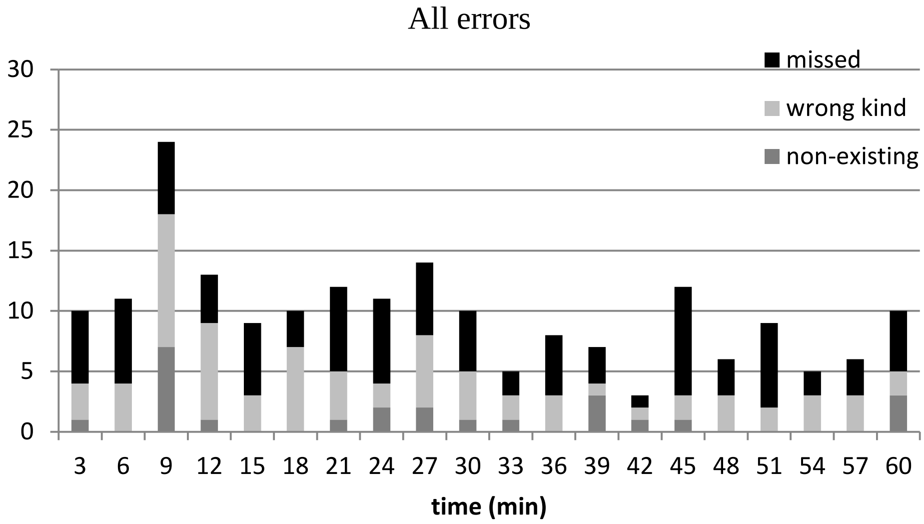


Figure 6. *Type of referees' mistakes during a match (per minute)*

Conclusions

We observed that the number of *serious* errors per match is similar to the number of non-consensual observations made by experts. So as the examiners are a tool to rank and develop the referees, some care must be exercised. These findings enforce the need for more collective decision making analyses to develop a more consensus interpretation of the games' rules.

Acknowledgment

We want to publically express our gratitude to the all the referees and examiners involved in this study. Their dedication was remarkable. We also want to highlight the essential support received from the Portuguese Handball Federation, namely through Henrique Torrinha, Prof. Pedro Sequeira and António Goulão.

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THE MECHANISM BEHIND THE HANDBALL GOALKEEPER'S DECISION PROCESS DURING A SEVEN-METER THROW

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Summary
To investigate whether the goalkeeper in a seven-meter penalty can decide based only on the free ball trajectory or if it must include a heuristic reasoning based on the thrower actions. Data was collected with a set of video cameras, EMG sensors and accelerometers synchronized. Results shows that men – contrary to women - have insufficient time to decide, start moving and reach a position that allows a successful action above random if based only on the free ball trajectory.

Keywords
Handball, goalkeeper, reaction time

Introduction
In several team sports, speed and accuracy of motor action (technical or tactical) are critical to achieve advantage relative to the opponent. But the time need to process several different types of information and sources, and start an adequate response recurrently exceeds the time available to answer (Williams, Davids and Williams, 1999). Therefore coaches, players and researchers agree that the capacity to anticipate the opponent actions is an essential skill to successful performance. In team handball a player action is not only constrained by the opponent action or intentions but also by a more complex interaction between players of a same team and opponents. Even in the case of goalkeepers, in some defensive situations their decisions consider not only the action of the player carrying the ball also the behaviour of the defensive players (Rogulj, Papic , & Srhoj, 2005). For example, the defence players commonly try to force or constrained the throwing action in order to reduce angle and/or increase the distance from goal. Moreover the ability to anticipate the type of throw and the time of ball release are extremely important for a handball goalkeeper success. As we know the ball takes around 0.3s from leaving the hand and entering the goal in a seven-meter throw (considering a standard throwing ball velocity of about 90km/h) and the goalkeeper will take around 0.1s to make a decision and start an action. And it will take more than that for the relevant limb to reach the ball trajectory. So it is required that the goalkeeper predicts the opponent intentions, selecting the clues perceived, before the ball leaves the hand. This is where deception strategies enter. In a somehow contradicted way, in handball, goalkeepers are commonly instructed to maintained their defensive position and delay their movement until the point when it would be hard for the thrower to modify the trajectory of ball (Savelsbergh et al., 2005; Schorer et al., 2007)). Additionally for maximise their chances to intercept to ball the goalkeepers adopt positional strategies to decrease uncertainty about ball' trajectory (Gutierrez-Davila et al., 2011). Most of the approaches try to understand how individual make anticipate judgments about the opponent actions or intention in sports used laboratory film-based occlusion tests (see Abernethy & Zawi, 2007; Abernethy, Zawi, & Jackson, 2008). Similarly, recently researchers (e.g., Huys et al., 2009; William et al., 2009) investigate the anticipation by manipulating the displayed information, by the use of Principal Component Analysis to identify the appropriate information source to occlude or neutralize. Although

advantages introduced by the aforementioned studies, the researchers did not achieved the corresponding time when the information should be extracted from the display, which problem was addressed by Bourne et al. (2011). Another approach is based on virtual reality technology to investigate the relation between handball throwing kinematics and goalkeepers' reactions (Bideau, et al., 2004). However, all research efforts done in this area, to better understand the strategies used in real duel situations more realistic scenarios must be investigated.

Methods

Sample

A set of 13 throwers (6 best Portuguese senior females and 7 best Portuguese junior males) and a set of 9 goalkeepers (5 male and 4 female) participated in this study, three of each per evaluation session.

Procedures

In each session there were two setups: a *regular* 7m shot to the goal – in an official court, with an official ball, standard illumination, etc. – and a *blind* setup were, at the 7m line there was device that did not disturb the thrower but did not allowed the goalkeeper to see the thrower (figure 1). Every shot to goal was preceded by a sound from a whistle, like in a match.

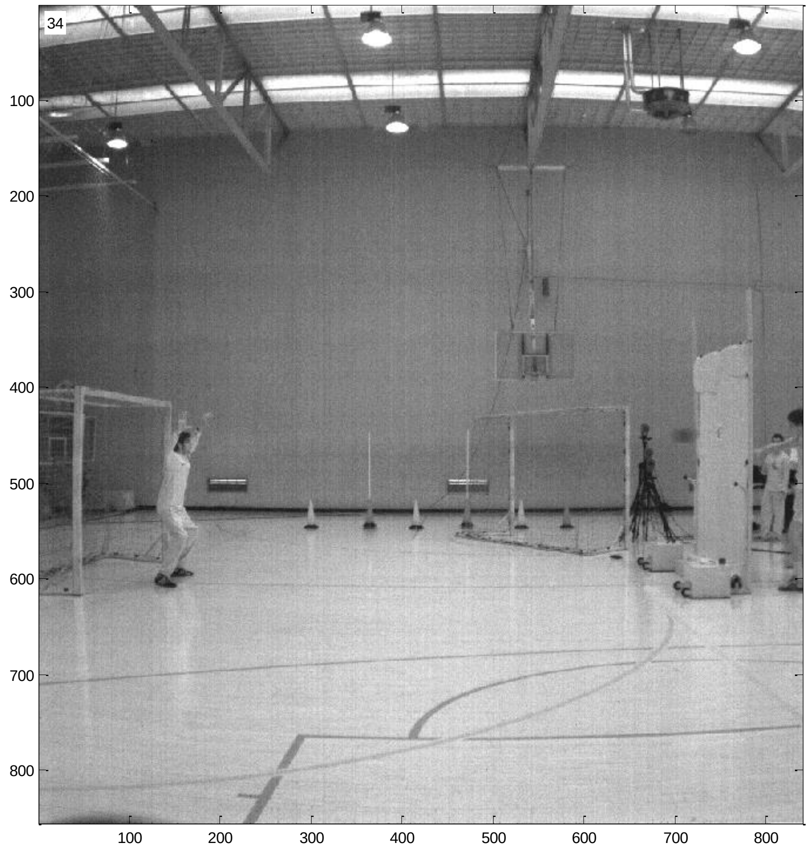

Figure 1 – *Blind* setup: a paper curtain

The sequence of events – goalkeeper/thrower/setup – was completely randomized, with each player having between 1min and 5min intervals between shots.

The scene was recorded with 3*3 high speed video cameras (working at 200 fps in the visible range). Each goalkeeper was carrying a set of 6 wireless EMG sensors (*biceps brachii, latissimus dorsi, gastrocnemius medialis*) and 4 wireless three-axial accelerometers (wrists and ankles) sampled at 296 samples per second. All devices (cameras, EMG and accelerometers) were electronically synchronized i.e., shared a common time base.

Main results and conclusions

The preliminary results about the ball's velocity show, without surprise, that women shot at goal at lower velocities than men – a difference of about 25%.

The curtain (that does not absorb any significant amount of energy from the ball) seems to need some adaptation as the shots with it are slightly slower than without it. This difference fades with practice.

	***Blind* female shots**	***Regular* female shots**	***Blind* male shots**	***Regular* male shots**	Experimental uncertainty
Ball velocity (km/h)	62	67	78	86	7
Reaction time (ms)	139	-	133	-	5
Goalkeeper efficiency	25%	29%	18%	17%	

The reaction times of male and female are similar (almost within the experimental uncertainty). As we know that the female goalkeepers are much better than the evaluated male goalkeepers, it seems that the reaction time is of little relevance to the goalkeepers efficiency. However, when the reaction time is exhausted, the ball has moved 2.5m (females) to 3m (males). It will reach the goal in about 0.4s (females) to 0.3s (males), and the body parts still need to move to the interception place.

What is apparent from this exercise is that females have time to react to the real ball trajectory while men do not, at least in the case of *difficult* shots. So men *must* speculate, from the movements of the thrower, what the balls trajectory will be, while women can probably guess less and react more.

To have similar decision time than women, men must speculate and make a decision 60ms *before* the ball is launched. This is a huge time and in a fast throw coincides with the final launch of the arm. This is where the thrower's deception strategies can be most efficient.

Figure 2 – Beginning of decision phase for a goalkeeper

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SELECTED EXTERNAL LOAD INDICATORS OF A BACK PLAYER, WING PLAYER AND LINE PLAYER IN THE WORLD WOMEN´S HANDBALL

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Summary
The aim of the paper was to analyse the level of physical contact with defender at individual offensive actions with regard to players´ posts. To obtain data we used the method of indirect observation using DVD recording. We watched the pre-Olympic tournament in London. The group consisted of four representative teams of women (Slovakia, Poland, China and United Kingdom). From the result we found that the passes in gradual attack have most always been carried out without contact with the defender (72% - 94%). The rest of game activities in gradual attack players realized with contact of the defender (line players 100%, back players 84%, wing players 55%). In counter-attack lower level of physical contact with the defender was recorded in comparison with gradual attack.

Keywords
Women´s handball, back player, wing player, line player, offensive game activities, level of contact with defender

Introduction
According to Czerwinsky (1996) handball is considered as an athletic game, which lays high requirements on physical and functional abilities of a player. Michalsik, Madsen, Aagaard, (2011) observed loading of female handball players in Danish top league during 5 years. Handball players were divided according to players´ posts (back player, wing player, pivot). Heart rate was also monitored. They found that handball players covered during the match the distance of 4,002.4 ± 332.6 meters, while changing the physical activity every 4.6 seconds. Average length of sprint was 6 meters. Heart frequency of players was 170.5 ± 7.2 pulses per minute.

High loading during the match, however, is not the result of only running itself and the change of rhythm and direction of movement, but mainly frequent physical contact with the opponent. Handball players come into contact with the opponent in a direct combat in offensive and defensive phases of the game. In our work we focused on the realization of offensive actions of an individual in relation to defensive activity of the opponent.

Methods
Ex post facto cross-sectional research pattern was used. The level of physical contact with the defender in gradual attack during the whole match, especially in the post of left back player, left winger and pivot was observed. If the player on the observed post was replaced, we continued in the observation. Advance attack was commenced in the moment, when the opponent´s defense was formed in the basic position of the defensive system. Contact with the defender was registered in selected individual game actions: passing, shooting and faking (feinting) with a ball. Experimental group was formed by the representative team of women, which participated in the pre-Olympic women´s tournament in London (November 11 till 27, 2011). The observed data were obtained from three matches: Slovakia – China, Slovakia – Poland and Slovakia – Great Britain. In each match offensive and defensive activity of both

teams was monitored using DVD recordings, which were carried out directly at the tournament. The level of physical contact with a defender was assessed in 4 levels:
I – The level without physical contact with the defender. Upon realization of offensive actions, the player was not in physical contact with the defender.
II - The level of physical contact. Physical contact – termination of the action**.** The player was in physical contact with the defender, however, the game was not interrupted by the referee at offensive action.
III – The level of physical contact. Physical contact – breaking the action using legal means. The player was in physical contact with the defender, who broke the attacking player´s action without progressive punishment.
IV – The level of physical contact. Physical contact – breaking the action using illegal means. The player was in physical contact with the defender, who interrupted it using illegal means, for which he was punished progressively (warning, 2 min. elimination, disqualification).
The data obtained based on the observation of game performance were recorded in the recording form. For the processing of the data basic mathematic and statistical methods were employed.

Results
The most frequent action of the back player in the match was passing (105 passes in a match), while the least frequent one was faking with ball (tab.1). However, it was surprising that up to 94% of passes was realized by back player without any contact with the defender. On the contrary, faking action with a ball was executed by the back player in 69% cases with physical contact of the defender and the consecutive interrupting of the action. Realization of shooting was peculiar because the majority of shooting attempts (67%) were realized after physical contact with the completion of the gaming activity (without the consecutive interruption of play).

Table 1 *Game activity and the level of physical contact of back player with defender*

The level of contact with defender / **Gaming activities**	**I**	**II**	**III**	**IV**	**Average activity for the match**
Pass	94%	6%	0	0	105
Faking (feinting) with a ball	0	13%	79%	8%	4
Back area shooting	15%	67%	9%	9%	13.3
All gaming activities	81%	15%	3%	1%	122.3
Gaming activities without passes	16%	51%	26%	7%	17.3

Since up to 90% of all offensive actions were formed by passing carried out mainly without physical contact with the defender, we decided to assess shooting and faking action with the ball independently (fig. 1). We found out that up to 84% of offensive activity (except for passing) is carried out by the back player under physical pressure of the defender. Defensive activity of the opponent is mostly realized with the completion of action without the following interruption of the play.

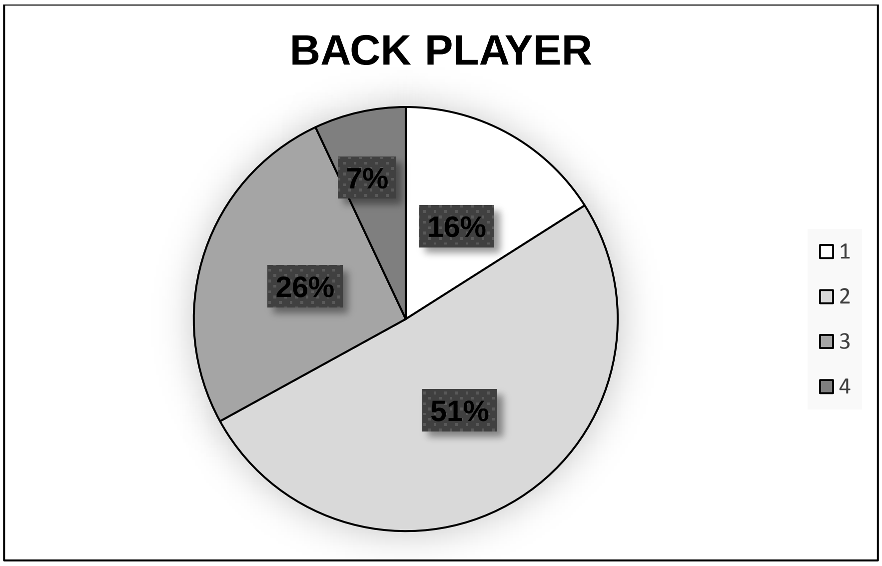

Figure 1 *The level of physical contact of back player with defender (without passes)*

The wing in gradual attack did not pass so frequently as the back player. This accrues from the basic position of the wing in the corner of the playground (tab. 2). Up to 17% of passes were realized by the wing upon physical contact with the defender. Shooting was executed by the wings mostly without physical contact (25%) or with physical contact of the defender and the consecutive completion of the action (48%). Only 27% of shooting was interrupted by the defender using both legal and illegal play.

Table 2 *Game activity and the level of physical contact of wing player with defender*

The level of contact with defender / **Gaming activities**	**I**	**II**	**III**	**IV**	**Average activity for the match**
Pass	83%	10%	7%	0	13.3
Faking (feinting) with a ball	29%	29%	27%	15%	6.8
Wing area shooting	25%	48%	12%	15%	8.14
All gaming activities	70%	13%	12%	5%	28.24
Gaming activities without passes	45%	17%	24%	14%	14.94

Also in case of the wing players we assessed the level of physical contact with the defender in the gradual attack without passing separately. Contrary to the back player we found out that up to 45% of observed offensive actions (shooting, faking action with the ball) were realized by the wings without physical contact with the defender. Second most frequently observed action (25%) was interrupting the attacking action of the wing using legal means (fig. 2).

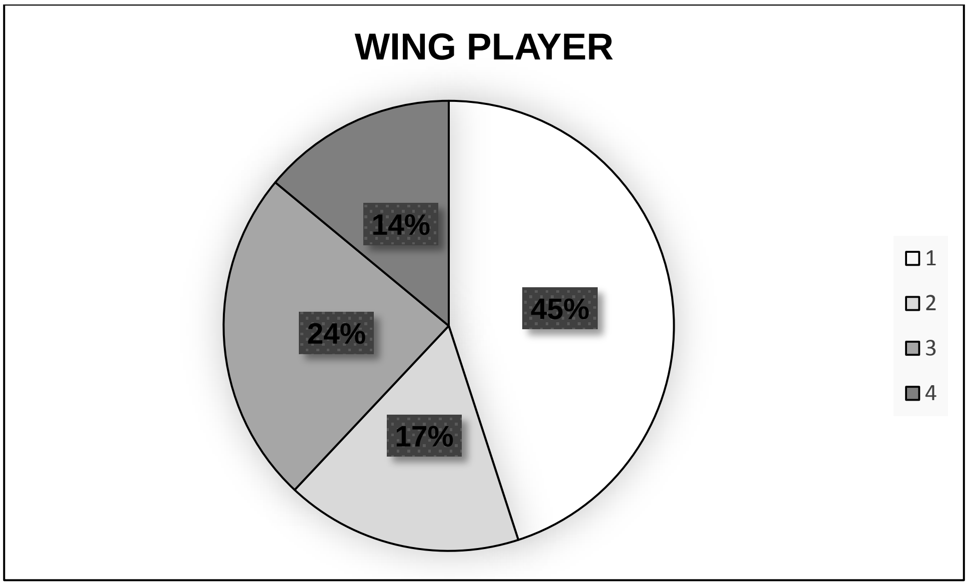

Figure 2 *The level of physical contact of wing player with defender (without passes)*

The movement of pivot in front of the goal area line suggests that the majority of offensive actions should be realized with physical contact of the defender. We found out that this is not the truth. Passing was realized by the pivot in 72% cases without contact with the defender. However, obviously here belong also free throw, but also frequent starting off from open defensive systems of the opponent and the consecutive passing mainly with the back players (tab. 3)

Table 3 *Game activity and the level of physical contact pivot with defender*

The level of contact with defender / **Gaming activities**	**I**	**II**	**III**	**IV**	**Average activity for the match**
Pass	72%	26%	2	0	13.43
Faking (feinting) with a ball	0	0%	60%	40%	2.5
Pivot area shooting	0%	43%	47%	10%	1.48
All gaming activities	57%	22%	15%	6%	17.41
Gaming activities without passes	0%	13%	61%	26%	3.98

The remaining observed actions (shooting, faking with the ball) are realized by the pivot exclusively under physical pressure of the defender (fig. 3). We found out that the level of physical contact with the interruption of the action using legal means was the most frequent (61%).

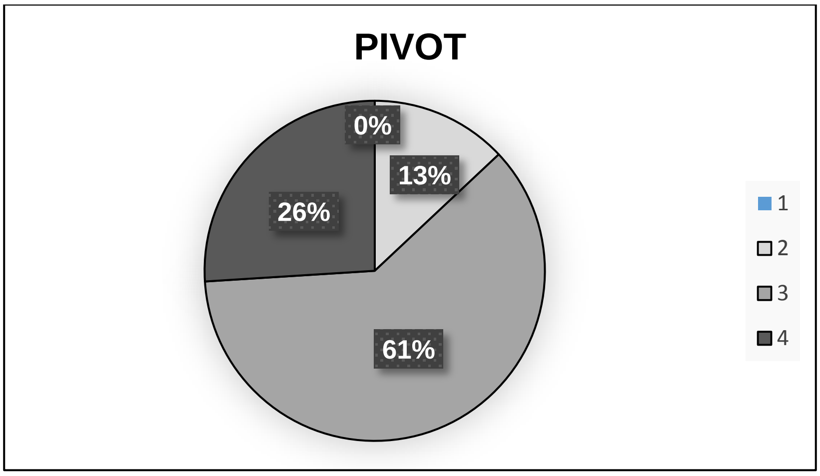

Figure 3 *The level of physical contact of pivot with defender (without passes)*

Discussion

Offensive actions of handball players at the pre-Olympic tournament in London were observed, while we focused on the level of physical contact with the defender in gradual attack. We thus assume that action under physical stress of the defender markedly increases loading in the match. Therefore, current teams try to be successful in counter-attacks at which there comes to rare contacts with defenders.

When observing passing, we recorded an interesting fact. Except for the fact that passing was the most frequently occurring offensive action, back players (94%), wing players (83%) and pivot (72%) executed passes mainly without the contact with the defender. Only pivot, whose basic position is in the close distance from the opponent´s defense, recorded 26% passes at the level of physical contact with the defender and the following completion of action without interruption of the play.

Difference in the realization of offensive actions with regard to players´ functions was also a significant finding. Wing players execute the majority of observed actions (without passing) without physical contact with the defender (45%), back players realize up to 51% of observed offensive actions at the level of physical contact without the following interruption of the play, and pivot execute up to 61% of the same actions after the interruption of the play using legal means. Differentiation of the training load as to players´ posts with regard to physical contact with the defender should also be taken into account. Elite back players and line players should practice exclusively under physical pressure of the opponent.

Conclusions

We watched the pre-Olympic tournament in London. The group consisted of four representative teams of women (Slovakia, Poland, China and United Kingdom). From the results we found that the passes in gradual attack have most always been carried out without physical contact with the defender (72% - 94%). The rest of game activities in gradual attack players realized with physical contact of the defender (pivot 100%, back players 84%, wing players 55%). In counter-attack lower level of physical contact with the defender was recorded in comparison with gradual attack.

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THE RELATION OF WOMEN TEAM MATCH PERFORMANCE INDICATORS TO THE RESULT OF THE MATCH IN HANDBALL

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Summary

The aim of the paper was to find out the connection between a match result and team match performance in the world women´s handball. Team match indicators were hierarchically divided into general, main and additional ones. For evaluation we used a computer program. Based on the data obtained we have shown that match result significantly relates ($p<0.05$) with all general team match performance indicators. When evaluating main indicators match result significantly depends on the success of fast break, in defensive phase on the defending of gradual attack and counter attack. In goalkeepers match performance significantly depends on effectiveness of goalkeepers´ saves.

Keywords

Women´s handball, team match performance indicators, offensive phase of game, defensive phase of game, goalkeeper

Introduction

A team's performance in sports games, specifically its identification and evaluation has been a long-term matter in the world of sports. The team is being monitored by their activity, which can have a substantial influence on the course of a match and especially on its final result. The evaluation of a team's playing performance is based on a method of evaluating crucial cases of successful and unsuccessful game situations. A crucial case (indicators) is considered as one that markedly enables or prevents reaching an aim in the match. Even though a crucial case in handball is evaluated by a highly qualified specialist, it should be able to be monitored relatively easily and defined clearly.

The issue women´s handball is included in the works of following authors: Táborský (1981, 2009), Brings, Platen, Hofmann (1998), Michalsik, Aagaard, Madsen (2011), Foretic, Rogulj, Srhoj (2011), Marczinka (2011).

Hianik (2010) monitored the relation between successful offensive and defensive game activity and the final match result. In his works a criterion for success was stated as depending upon either a successful or unsuccessful solution of offensive and defensive game action. One of Hianik's findings was a higher partial influence of unsuccessful offensive and defensive game actions for the final match result.

Methods

To obtain the result of the work we used a retrospective research on ex post facto. Viewed team was national women´s team of Slovakia. The observation we made during two years

(2011 – 2013) of competition. We analysed 16 handball matches. Team Slovakia won 8 games and 8 lost. Assessment game team performance, was analysed by the video. We used a computer program created in Microsoft Excel spreadsheet. Every match was evaluated by the same pair of expert: head coach and his assistant. To observe the match performance indicators we concentrated on "techniques of critical incident", this theory elaborated Flanagan (1954). Match performance in team handball is simply expressed by winning the match and lose. However, it is expressing its relative value. It is different to play against strong opponents and weaker ones. In handball is therefore more advantageous to create a sub-match performance, so- called team match performance indicators which have decisive importance for the match performance team (Táborský, 2009).

Indicators the team match performance in handball

Offensive phase of the game

The team's match performance in offensive phase of the game we followed through 22 indicators, including 12 positive and 10 negative (Table 1).

Table 1 *Indicators in the offensive phase of game*

Offensive phase of the game	Positive evaluation	Negative evaluation
Back area shooting	+	−
Wing area shooting	+	−
Pivot area shooting	+	−
Breakthroughs shooting	+	−
Fast Breaks shooting	+	−
7 metre Shots	+	−
Assistance	+	
Received 7m-Fouls	+	
Rebound in attack	+	
Turnover		−
Attack Interruption	+	−
2 Minute Suspensions: opponent-own	+	−
Disqualified: opponent-own	+	−

Defensive phase of the game

The team's match performance in defensive phase of the game we followed through 17 indicators, including 9 positive and 8 negative (Table 2).

Table 2 *Indicators in the defensive phase of game*

Defensive phase of the game	Positive evaluation	Negative evaluation
Individual improvement activities defending	+	−
Basic attack combinations defending	+	−
Special attack combinations defending	+	−
Blocked Shots	+	−
Rebound defending	+	−
Steal Ball	+	
7 metre foul		−
2 Minute Suspensions: opponent-own	+	−
Disqualified: opponent-own	+	−
Unenforced opponent's turnover	+	

Match performance of goalkeeper

Match performance of goalkeeper we followed through 27 indicators, including 14 positive and 13 negative (Table 3).

Table 3 *Indicators of the match performance of goalkeeper in the game*

Goalkeeper	Positive evaluation	Negative evaluation
7 metre Penalty Shots	+	−
Fast Breaks Shots	+	−
Breakthroughs Shots	+	−
7-9 metre Shots	+	−
9 metre Shots	+	−
Wing Shots	+	−
Pivot Shots	+	−
Make Fast Breaks	+	−
Assistance	+	
Steal Ball	+	
Turnover		−
Goalkeeper defending in Field	+	−
Goalkeeper Shooting	+	−
2 Minute Suspensions: opponent-own	+	−
Disqualified: opponent-own	+	−

The criterion of success indicators have been successful for us (+) or unsuccessful (−) solution of game situations. The processing and evaluation of the work we used the following methods:

- frequency analysis of observed match performance indicators and testing the level of association between the success of match performance indicators to the final match result [chi – square (X^2)] in tabular representation,
- with statically significant result, we determined the proportion of the total value of X^2,
- we evaluated the significance of differences at 5% [*] and 1% [**] level of statistical significance.

Results

We watched the handball match performance of woman national team Slovakia in the qualification and preparatory matches for the World Championships and European Championships. In total we recorded 4.024 indicators including the offensive phase of the game was 1.597, in the defensive phase of the game 1.684, in the match performance of goalkeepers 743.

Table 4 *Relationship between success indicators match performance team and the final match result.*

Indicator	*Number*	X^2		
		Total	Unsuccessful	Successful
Offensive phase of game	1.597	**7.68****	4.37	3.31
Defensive phase of game	1.684	**37.97****	23.18	14.79
Goalkeeper	743	**18.49****	8.56	9.93

The relation of team match performance indicators in offensive phase of game on the final match result

In the gradual attack the final match result wasn´t significantly depended on the indicators of the reference of the observed team (Table 5).

Table 5 *The relation of team match performance indicators in gradual attack of game on the final match result*

%	Unsuccessful	Successful	*Number*		X^2	Unsuccessful	Successful	*Total*
Lose	52%	48%	458		Lose	0.03	0.03	0.04
Win	50%	50%	339		Win	0.04	0.04	0.08
Number	408	389	797		*Total*	0.07	0.07	0.13

Conversely in the counter attack the final match result was significantly ($p < 0.05$) depended on the indicators of the reference observed team (Table 6). We note the superiority of successful solutions for the indicators (66%). The highest proportion was in winning matches (71%).

The highest impact on the final result of the match we registered in unsuccessful realization of performance monitoring indicators (X^2=4.26).

Table 6 *The relation of team match performance indicators in counter attack of game on the final match result*

%	Unsuccessful	Successful	*Number*		X^2	Unsuccessful	Successful	*Total*
Lose	40%	60%	224		Lose	2.47	1.25	3.72
Win	29%	71%	308		Win	1.79	0.91	2.7
Number	179	353	532		*Total*	4.26	2.16	**6.42***

The relation of team match performance indicators in defensive phase of game on the final match result

In the defence of gradual attack of the game the final match result was significantly ($p < 0.01$) depended on the indicators of the reference observed team (Table 7). In the defence of gradual attack we have seen up to 63% of successful solution in the indicators. The highest proportion was in winning matches (69%). The highest impact on the final result of the match we registered in unsuccessful realization of performance monitoring indicators (X^2 = 11.11).

Table 7 *The relation of team match performance indicators in defence of gradual attack on the final match result*

%	Unsuccessful	Successful	*Number*		X^2	Unsuccessful	Successful	*Total*
Lose	44%	56%	445		Lose	5.81	3.43	9.24
Win	31%	69%	488		Win	5.3	3.12	8.42
Number	347	587	933		*Total*	11.11	6.55	**17.67****

In the defence of counter attack of the game the final match result wasn´t significantly depended on the indicators of the reference observed team (Table 8).

Table 8 *The relation of team match performance indicators in defence of counter attack on the final match result*

%	Unsuccessful	Successful	*Number*		X^2	Unsuccessful	Successful	*Total*
Lose	64%	36%	205		Lose	0.35	0.55	0.9
Win	57%	43%	153		Win	0.46	0.73	1.19
Number	219	139	358		*Total*	0.81	1.28	2.09

The relation of match performance indicators of goalkeeper on the final match result

In the match performance of goalkeeper saves the final match result was significantly ($p<0.01$) depended on monitored indicators of the goalkeepers (Table 9). We note the predominance of the unsuccessful solution in monitored indicators (63%).

The highest influence on the final result of the match we registered in successful realization of the performance monitoring indicators ($X^2 = 8.04$).

Table 9 *The relation of match performance indicators of goalkeeper saves on the final match result*

%	Unsuccessful	Successful	*Number*		X^2	Unsuccessful	Successful	*Total*
Lose	69%	31%	346		Lose	2.09	3.55	5.64
Win	55%	45%	247		Win	2.65	4.49	7.14
Number	390	230	620		*Total*	4.74	8.04	**12.78****

In the further action by the goalkeeper the final match result wasn´t significantly depended on the indicators of the reference observed team (Table 10).

Table 10 *The relation of match performance indicators of further action by the goalkeeper on the final match result*

%	Unsuccessful	Successful	*Number*		X^2	Unsuccessful	Successful	*Total*
Lose	11%	89%	56		Lose	0.92	0.07	0.99
Win	4%	96%	68		Win	0.76	0.06	0.82
Number	9	115	124		*Total*	1.68	0.13	1.81

Conclusions

The match performance of field players (offensive and defensive phase of the game), we have seen significant relationship unsuccessful realization of monitored performance indicators on the final match result. Most we´ve had in the defensive phase of the game. The match performance indicators of goalkeeper saves confirmed the significant relationship of successful solutions in the monitored indicators on the final match result.

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PROPOSAL ON THE ANALYSIS OF OFFENSE SET-PLAY USING SEQUENCE ANALYSIS

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Summary
The purpose of this study was to analyze the relationship between multiple attacking play actions using sequence analysis for evaluating the attack aspect of offense set-play in handball. We classified into twelve types of attacking play action and performed the sequence analysis of attacking play actions in a chronological order. Therefor, the specific combined multiple attacking play actions in offense set-play existed. In conclusion, it may use the sequence analysis for evaluating the attack aspect of offense set-play.

Keywords
Key notational analysis, sequence analysis, offense set-play

Introduction
Recent studies have used a notational analysis to analyze performance in ball sports. In handball, the number of scored goals (Taborsky, F. and Hoffmann E.,2003; Meletakos, P. and Bayios, I., 2010) and the distribution of successful shooting play spaces (Meletakos, P., et al., 2011; Foretić, N., et al., 2010; Ichimura, S., 2011) have been studied. In generally, a notational analysis could assess the total tactical behavior and the important aspects of the game to evaluate the single actions. In order to gain deeper insight into the tactical behavior of the individual and team, it is necessary to record the multiple tactical actions and to analyze the sequence of attacking play actions in chronological order.

In a previous study, there are studied the relationship between the sequences of the actions in between situations on the net sports as beach volleyball (Koch, C. and Tilp, M.,2009). In addition, the sequences of attacking actions in handball are studied using artificial neural networks (Pfeifferm. M and Perl. J., 2006).

In this study, in order to aim to establish a method for evaluating the attack aspect of the offense set-play in handball, we classified into twelve types of attacking play action and performed the sequence analysis of multiple attacking play actions in a chronological order.

Methods
Sample
There were analyzed the offense set-plays of Brazil (BRA), South Korea (KOR), Montenegro (MNE), Norway (NOR) and Spain (ESP) women's teams in 2012 London Olympic games. We categorized 5909 attacking play actions out of 1631 offense set-plays, were performed by 25 games from five nations (each five games).
The classification of attacking play action
The attacking play actions during the offense set-play were classified into the 12 types of attacking play actions, according

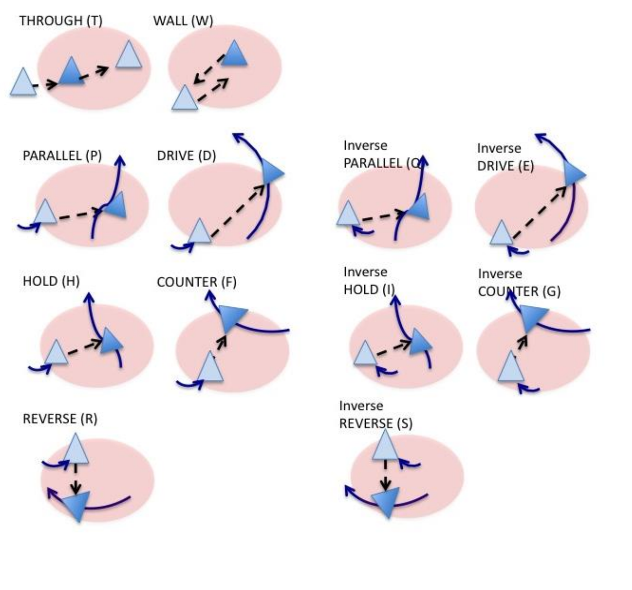

Figure 1 classification of attacking play action
Twelve types of the attacking play actions during the offense set-play according to the moving and throwing directions on previous player and the attacking direction of player while receiving a ball.

to the moving and throwing directions on previous player and the attacking direction of player while receiving a ball (Figure 1).
The classification as follows;

The situations where there was no attacking intention in the ball holder
THROUGH (T) as a throwing the ball in the same direction to the previous player action with less movement after receiving the ball, WALL (W) as a throwing the ball in an opposite direction to The previous player action with less movement after receiving the ball.

The situations where it was similar between the moving and throwing directions on the previous player and the attacking direction of player, while receiving a ball
PARALLEL (P) as an attacking action in the same direction to the previous player action after receiving the ball, DRIVE (D) as an attacking action in the same direction to the previous player action while receiving the ball, HOLD (H) as an attacking action in an opposite direction to the previous player action after receiving the ball, COUNTER (F) as an attacking action while receiving the ball which moving to cross in front of a passer、REVERSE (R) as an attacking while receiving the ball which moving to cross in backward of a passer.

The situations where it was not similar between the moving and throwing directions on the previous player and the attacking direction of the player, while receiving a ball
Inverse PARALLEL (Q) as an attacking action in an opposite direction to the previous player action after receiving the ball, Inverse DRIVE (E) as an attacking action in an opposite direction to the previous player action while receiving the ball, Inverse HOLD (I) as an attacking action in the same direction to the previous player action after receiving the ball, Inverse COUNTER (G) as an attacking action while receiving the ball which moving to cross in front of a passer、Inverse REVERSE (S) as an attacking while receiving the ball which moving to cross in backward of a passer.

Sequence analysis
We lined up the multiple attacking play actions in a chronological order during each offense set-play (Figure 2). The sequence of attacking play action during offense set-play was divided into the sequence codes of two, three, four, and five characters (alignment). In this study, each sequence code showed that used more than 1%.

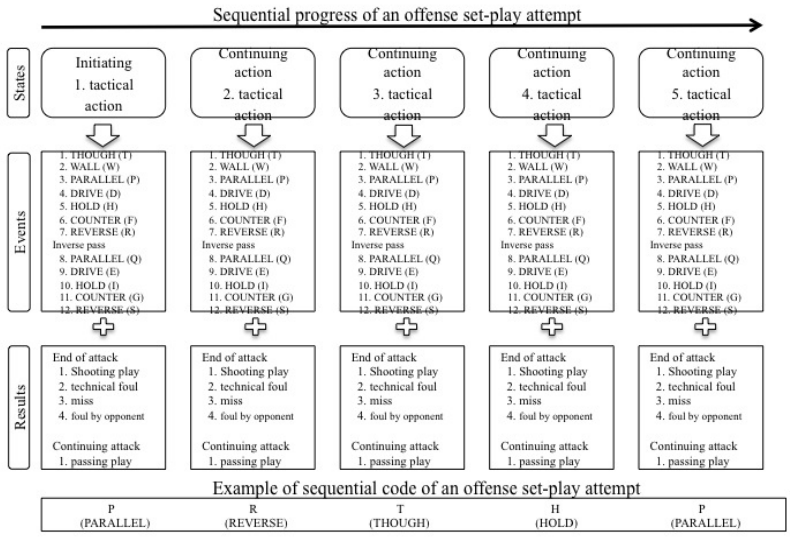

Figure 2 Model of an offense set-play using a sequence of states
If attacking play actions were PARALLEL in initiating phase (1st tactical action), REVERSE in continuing phase (2nd tactical action), THOUGH in continuing phase (3rd tactical action), HOLD in continuing phase (4th tactical action) and PARALLEL in ending phase (5th tactical action), we showed the P-R-T-H-P.

Results
The number of offenses set-play and the attacking play action
The offense set-plays number which the attacking play action ended in first, second, third, fourth or fifth attacking play action were 242 (14.8%), 344 (21.2%), 339 (20.8%), 250 (15.3%) or 167 (10.2%) times, respectively. There were 82.3% of all offense set-play.

The numbers of sequence codes in two, three, four, and five characters were 1390 times in the sequence code in two characters, 1045 times in sequence code in three characters, 707 times in the sequence codes in four characters and 457 times in the sequence code in five characters.

The distribution of the frequency in use of the sequence code in attacking play action

The distribution of frequencies of twelve types of single character during first, second, third, fourth, and fifth attacking play action were presented in Table1.

The frequency in use of the sequence code in two characters that observed more than 1% demonstrated in figure 3. The kinds of sequence code in two characters that observed during the initiating were 16 kinds. The distribution of frequency in use of sequence codes in two characters that observed more than 1% were 93.9%. The most observed the sequence codes in two characters were the H-* (H-P, H-H, H-R, H-T, and H-I) and P-* (P-R, P-H, P-Q, P-I and P-P) and F-* (F-R, F-H) but less observed the other sequence codes in that (Figure 3).

Figure 4 showed the frequency in use of sequence codes in three characters. The kinds of sequence codes in three characters that observed more than 1% were 36 kinds. The distribution of frequency in use of sequence code in three characters that observed more than 1% was 76.0%. The most observed the sequence codes in three characters were the H-H-* (H-H-H, H-H-P, H-H-R, and H-H-I), H-P-* (H-P-H, H-P-P, H-P-F and H-P-R), P-R-* (P-R-T, P-R-W, P-R-H, P-R-P, P-R-P, P-R-D, P-R-F, P-R-R, and P-R-I), and F-R-* (F-R-H, F-R-P, F-R-R, and F-R-I) (see figure 4).

Figure 5 showed the frequency in use of the sequence codes in the four characters. The kinds of sequence codes in four characters that observed more than 1% were 16 kinds. The distribution of frequency in use of the sequence codes in four characters that observed more than 1% were 34.1%. The most observed the sequence codes in four characters were the H-P-*-* (H-P-H-P, H-P-R-H,), P-R-*-* (P-R-T-W, P-R-T-H, P-R-W-H, P-R-H-H, P-R-H-P, P-R-H-R, P-R-D-R, P-R-P-H, P-R-P-R) (see figure 5).

The kinds of sequence codes in five characters that observed more than 1% were 9 kinds, respectively. The distribution of frequency in use of sequence code in five characters that observed more than 1% was 13.8%. The most observed the sequence codes in five characters were the P-R-T-*-* (P-R-T-W-P, P-R-T-W-H and P-R-T-H-P) and P-R-W-*-* (P-R-W-H-P and P-R-W-H-H).

	t	w	h	p	d	f	r	i	q	e	g	s	CV
1st attaking play acton	0.1	0.3	46.3	43.0	0.1	10.2	0.0	0.0	0.0	0.0	0.0	0.0	206.8
2nd attaking play acton	4.4	3.9	17.3	18.8	1.3	1.8	39.4	6.9	5.4	0.5	0.2	0.1	139.5
3rd attaking play acton	7.6	7.3	31.5	18.4	4.7	5.4	13.3	6.8	4.5	0.1	0.5	0.0	108.5
4th attaking play acton	6.4	6.4	30.6	20.1	1.7	3.8	18.5	6.9	4.2	0.1	1.3	0.0	115.2
5th attaking play acton	7.4	5.0	29.8	30.4	2.6	4.8	8.8	5.7	4.8	0.0	0.7	0.0	126.4
AVE	5.2	4.6	31.1	26.1	2.1	5.2	16.0	5.3	3.8	0.1	0.5	0.0	125.0
CV	60.6	59.2	33.1	40.7	81.9	59.4	92.1	56.8	57.0	140.4	92.9	223.6	

	t	w	h	p	d	f	r	i	q	e	g	s	CV
last attaking play action	0.7	0.2	31.4	26.8	3.0	9.0	12.9	9.4	5.0	0.1	1.5	0.1	127.6

Table 1 The frequencies in use of the attacking play action during first, second, third, fourth and fifth tactical actions (attacking play action).

	t	w	h	p	d	f	r	i	q	e	g	s	SUM	CV
t		0.1	3.3	0.6		0.4							4.4	259.4
w			1.8	1.6		0.5							3.9	202.7
h		0.1	9.2	5.6		2.4							17.4	205.8
p		0.1	15.0	2.6		1.1							18.8	274.2
d			1.1	0.1		0.1							1.3	286.4
f			0.9	0.7		0.1							1.8	215.1
r			7.7	25.9	0.1	5.7							39.4	231.4
i			3.1	3.6		0.2							6.9	225.8
q			0.9	4.2		0.4							5.4	267.0
e			0.1	0.4									0.5	258.0
g			0.2										0.2	346.4
s			0.1										0.1	346.4
SUM		0.3	43.4	45.4	0.1	10.9								
CV		195.4	128.6	190.9	346.4	183.0								

Figure 3 The matrix of sequence codes in two attacking play actions

The row demonstrated the first attacking play action (1st tactical action) and the column demonstrated the second attacking play action (2nd tactical action). The data were showed the percent of the use of the attacking play action.

	ht	hw	hh	hp	hr	hi	pw	ph	pp	pr	pi	pq	fh	fr	SUM	CV
t			0.5					0.5		3.8					4.8	410.0
w										4.6					4.6	509.9
h	2.7	1.7	1.8	4.1	1.4	1.1	1.6	1.4		7.8	1.1	1.1	1.1	1.8	28.7	154.2
p	0.9		1.8	3.1				1.7		5.8		1.6		1.1	16.0	215.7
d										3.0					3.0	509.9
f				1.3					1.0	1.1					3.4	285.3
r			1.2	3.2	1.1			1.0		2.8	1.1			1.1	11.5	197.4
i			1.2	0.8						1.1				1.0	4.1	243.6
q					2.3										2.3	509.9
e																
g																
s																
SUM	3.6	1.7	6.5	12.5	4.8	1.1	1.6	4.6	1.0	30.0	2.2	2.7	1.1	5.0		
CV	268.0	346.4	137.6	147.6	191.4	346.4	346.4	165.5	346.4	103.4	233.5	237.7	346.4	155.7		

Figure 4 The matrix of sequence codes in three attacking play actions

The row demonstrated the first and seconde attacking play actions (1st and 2nd tactical actions) and the column demonstrated the third attacking play action (3rd tactical action). The data were showed the percent of the use of the attacking play action.

	ht	hh	hp	hr	pw	ph	pp	pr	fr	SUM	CV
tw								2.5		2.5	412.3
th		0.4						2.3		2.7	349.2
wh								4.8		4.8	412.3
ht	0.4					0.3	0.3			1.0	228.1
hh								3.4	1.0	4.4	326.9
hp		1.1	2.3					1.6		5.0	233.2
hr					1.0			1.7		2.7	293.2
dr								2.0		2.0	412.3
ph		0.3				1.3		1.1		2.7	252.8
pf			0.8							0.8	412.3
pr								3.0		3.0	412.3
rh			1.0							1.0	412.3
ri			0.7							0.7	412.3
qr				1.4						1.4	412.3
SUM	0.4	1.8	4.9	1.4	1.0	1.6	0.3	22.4	1.0		
CV	400.0	259.0	208.2	400.0	400.0	330.5	400.0	108.4	400.0		

Figure 5 The matrix of sequence codes in four attacking play actions

The row demonstrated the first and seconde attacking play actions (1st and 2nd tactical actions) and the column demonstrated the third and fourth attacking play action (3rd and 4th tactical actions). The data were showed the percent of the use of the attacking play action.

Discussion

In this study, we found that the specific sequence codes of combined multiple attacking play actions in offense set-play existed to perform the sequence analysis.

In single attacking play action, the use in H, P, and F were observed at the first tactical action, and those operating ratios were more than 99% of the whole. The increase of the use in R, Q, T, and W of attack play action was observed at the second to fifth tactical action. The coefficients of variation at the each attacking tactical action were 206.8 at the first, and 139.5 at the second, 108.5 at the third, 115.2 at the forth, 126.4 at the fifth attacking tactical actions, respectively. The coefficient of variation at the first attacking tactical action was larger than those at others. Thus, the kind of the single attacking play action which were used by the second to fifth attacking tactical actions were greater than first attacking tactical action. In specific finding, the use in F and R, and I and Q with an inverse pass were tended to increase during the ending attacking tactical action (Table 1).

The first attacking play action almost were used the H, P, or F. And, the frequency of use in H, P, and R was greater although the various attacking play actions were used in the second attacking play action followed the firs attacking play action. The sequence codes in two continuous attacking play actions were H-H, H-P, H-R, P-H, and P-R. Thus, there were demonstrated that the two continuous attacking play actions were greater the frequency of used in the H-H, H-P, H-R, P-H, and P-R at the initiating tactics play.

Following, the third attacking play actions were used in T, W, H, P, D, F, R, I, and Q after the second attacking play action as H-H, H-P, H-R, P-H, or P-R. These results were demonstrated that a player that played at the third attacking play action have many play choices and has to choose a suitable play from many plays, in order to make an attack successfully. Thus, we suggest that the attacking play action at the third tactical play action was a key point of control in the offense set-play. And, a possibility of progressing to the fourth attacking play action is high when the third attacking play actions were the T, W, H, P, or R. The use in the others at the third attacking play actions was terminated at the third tactical play action.

The sequence codes at the fourth tactical play action that observed more than 1% were H-H-*-*, H-R-*-*, H-P-*-*, P-W-*-*, P-R-*-*, and F-R-*-*. We observed that it was made the many appearances of combined third and fourth tactical play actions, after the combined first and second tactical play actions was H-P or P-R. In contrast, the sequence codes at fourth tactical play actions were very little observed when H-R, P-H, and F-R were performed at the combined first and second tactical play actions. Thus, we speculate that the tactical play action was ended at the third attacking play action when the players performed using the sequence codes of H-P, P-H, and F-R at the first and second attacking play action.

In the sequence code at five continuous attacking play actions, the eight kinds of the sequence code that start with P-R at the first and second attacking play actions were observed among all nine kinds of that. And, the third attacking play action that followed P-R always contained T or W without an attack intention. We can show the P-R-T-*-* (P-R-T-W-P, P-R-T-W-H and P-R-T-H-P) and the P-R-W-*-* (P-R-W-H-P and P-R-W-H-H). From these results, we can speculate that the first and second tactical play actions perform the initiation for making an attacking space, and the third tactical play action exists for the continuing attacking play action, and fourth tactical play action also exists for making an attacking space, and the player that performed the attacking play action at third tactical play action can attack at the fifth tactical play action.

In conclusion, we demonstrated that it is able to use the sequence analysis for evaluating the attack aspect of offense set-play.

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THE EFFECT OF TRAINING LOADS ON THE PHYSICAL CAPACITY AND FITNESS OF YOUNG FEMALE HANDBALL PLAYERS DURING THE THREE-YEAR TRAINING CYCLE.

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Summary
The research was conducted on the students of sports class handball profile in Middle School nr 1 in Reszel from 2007 to 2010 year. For different reasons, only 11 out of 20 subjects completed all the tests within the 3-year period. The aim of the study was to determine the effect of the applied training loads on the changes of physical capacity and performance of the 13-15 years old female handball players within the three-year training cycle.

Keywords
Handball, training loads, physical capacity, physical fitness

Introduction
Composing an effective training load program over several years is crucial for conditioning and skills improvement of the players. Moreover, it is vital that the program prevents the players from temporal or sustained overtraining state. This problem especially regards the players of team games because of the complexity of the preparation system, in particular when young adolescent players are considered (Czerwinski and Jastrzebski, 2001).

It is very difficult to register the training loads in team games. Registration regards the volume and the intensity of the work performed. The volume can be expressed as the time of effective performance and is relatively easy to measure. However, the intensity needs a closer consideration. It usually requires the application of portable heart rate monitors, what can pose a problem because of a contact character of the game.

Exercises applied to the players induce adaptive changes in their bodies. It can be observed especially after one or several years training cycle involving generic and specific training. According to many authors, the optimal preparation of the handball female players requires a precise training plan that involves periodization of training loads and application of such exercise which would not cause sustained overtraing (Czerwinski and Jastrzebski, 2003).

The aim of the study was to determine the effect of the applied training load on the changes of physical capacity and performance of the 13-15 years old female handball players within the three-year training cycle. It was assumed that the physical capacity and skills would significantly improve as a result of applied training load and biological development of the subjects.

Material
The research was conducted on a sample of 20 female handball players, all students of sports class handball profile in Middle School nr 1 in Reszel from 2007 to 2010. For different reasons, only 11 subjects completed all the tests within the 3-year period.

During the first year, the training program weekly comprised 10 hours of physical education lessons, that included 6 hours of teaching and developing skills, and 4 hours of conditioning practice. During the second and third year of the study, the players participated in obligatory

PE lessons and additionally in 2 sports training sessions weekly and 2 sports camps: 10-day in summer and 7-day in winter.

The participants were selected to the sports class based on the results of three tests: pentajump, single-hand throw of a handball from a standing position (each hand) – (the distance covered by the ball), double-hand throw of a 2 kg medicine-ball from the front position and back position – (the distance covered by the ball). Moreover, three experts (coaches) observed the control game and assessed the girls under technical and tactic skills using the scale from 1 to 10 points. The players who scored most points were selected to the class (tab.1).

Tab.1. *Biometric characteristics of the handball players ($\overline{X}$ ±SD).*

One year training cycle	Calendar age [yrs]	Biological age [yrs]	Body height [cm]	Body mass [kg]
1. 2007/2008	13	14,5	164.6±6.27	53.81±8.17
2. 2008/2009	14	17,5	165.79±5.23	59.35±5.02
3. 2009/2010	15	18	167.90±4.22	59.00±4.83

Methods

The tests were conducted at the beginning of the preparatory season (date 1, 3, 5) and at the end of the competitive season (date 2, 4, 6) during each of the one-year training cycles.

The level of general fitness of the players was assessed with five different tests: strength test (strength endurance for women), power test (vertical jump), running speed test (60m run), speed endurance test (300m run), and agility test (zig-zak run) [Drabik, 1992].

The aerobic capacity was assessed with the use of Cooper test [1976], and sport specific skills were tested with Pytlik-Żarek test [1975]. Training loads were applied during the study according to the original program by the coach of the team. The biological age was applied by Cieslik et. al [1994] and modification of this method by Burdukiewicz et. al [2009].

All the results were statistically analysed with the use of mean and standard deviation values. Also significance of differences between the results were stated. The Shapiro – Wilk test was applied to check homogeneity of dispersion with normal distribution. The Levene test was used to check the homogeneity of the variance. An analysis of variance (ANOVA) was applied for the repeated measures. Statistically significant differences were determined with the application of post hoc (RIR) Tukey test. The significance was set at $p < 0,05$ (Statistica, V.9.0).

Results

Tab. 2 presents the results of five general fitness tests of the handball players within the three-year training cycle. The relevant improvement was observed for all these tests, and the biggest differences were revealed for arm strength and 300 m run.

Tab.3 shows the number of points scored for specific skills. The biggest improvement was observed after the first (date 1, 2) and the second year of training (date 3, 4). A substantial increase in aerobic endurance was also observed during the 3-year study, and the biggest improvement was observed after the first year.

Tab.2. *Results ($\overline{X}$ ±SD) of five general fitness tests of young handball players within the three-year training cycle.*

Date	Running speed test, 60m run (s)	Endurence test, 300m run (s)	Agality test, Zig-zac run (s)	Power test, vertical jump (s)	Strength test, press-ups against the bench (s)
1.	10.3±0.91$^{*1-2,4,5}$	58.7±4.72	25.7±2.03	38.6±5,35	16.0±6.47
2.	9.42±0,70$^{*2-3,5,6}$	54.5±3.35	24.0±1.40	41.2±5.38	20.0±6.38
3.	9.68±0,56	53.4±2.46	24.1±1.23	40.6±5.01	23.0±6.39
4.	9.47±0,60$^{*4-5,6}$	51.0±2.37	23.5±1.00	42.7±4.76	26.0±5.34
5.	9.88±0.67	50.8±2.03	23.7±1.02	41.7±4.45	26.0±5.39
6.	9.82±0.55	50.5±1.69	23.9±0.70	41.1±4.23	28.0±5.34

(*significant differences at $p < 0,05$).

Tab.3. *Results ($\overline{X}$ ±SD) of the distance covered in Cooper test [m] and points of the Pytlik-Żarek specific skills test scored by the young handball players during the three-year training cycle.*

Date	Pytlik-Żarek Test [pkt]	Cooper Test [m]
1.	213,73 ± 32,16$^{*1-2,3,4,5,6}$	2075,46 ± 330,04$^{*1-4,5,6}$
2.	250,50 ± 26,78^{*2-4}	2224,09 ± 308,04
3.	252,82 ± 21,57^{*3-4}	2282,27 ± 193,56
4.	271,05 ± 25,08	2359,09 ± 182,78
5.	261,23 ± 24,08	2356,36 ± 160,50
6.	263,64 ± 23,19	2344,09 ± 143,44

(*significant differences at $p < 0,05$).

Tab.4 presents the number of the training sessions applied within the time of the study. During the second and the third year, the number of training units increased by approximately 90 in comparison to the first year. Similarly, the number of competition matches and friendly matches increased.

Tab.4. *The number of training sessions applied to the handball players of the sports class in the Middle School Nr 1 in Reszel.*

Year of training	Number of training sessions a year	Number of competition matches	Number of friendly matches
1.	196	8	5
2.	286	19	11
3.	284	22	11

Workloads during the first year of training

During the first year, most training time was allocated for the general fitness practice (conditioning). The aim of these exercises was to improve general strength, coordination and flexibility of the players. Moreover, the young handball players developed their running speed and endurance speed. A lot of time was devoted for specific skills practice - teaching and development of individual technique (in pairs or groups with the application of small-sided games 1x1, 2x2, 3x3).

Tab.5. *The example of a one-week training microcycle of the handball players from the sports class of the Middle School in Reszel during the first year of training.*

Day of a week	Time of training	Type of training	Content	Organization
Monday	13.40-14.25 14.25-15.20	general general	General fitness General strength	in a group and individually
Tuesday	7.15-8.00 8.00-8.45	specific	Individual technique, atack, defence, throws	in a group and individually
Wednesday	7.15-8.00 8.00-8.45	specific	Individual technique, atack, defence, throws	in a group and individually
Thursday	7.15-8.00 8.00-8.45	general oriented	General fitness Development of general fitness components	in a group and individually
Friday	13.40-14.25	specific	Individual technique, atack, defence, throws	in a group and individually
Satursay, Sunday	competition			

Workloads during the second year of training

The main aim of the second year of training was to develop specific skills of the players: teaching and development of the technique, and improving specific fitness or strength. The number of the competition and friendly matches played during that year increased.

Tab.6. *The example of a one-week training microcycle of the handball players from the sports class of the Middle School in Reszel during the second year of training.*

Day of a week	Time of training	Type of training	Content	Organization
Monday	8.00-8.45 8.50-9.35	general oriented	general fitness general and specific strength	In a group in a group and individually
Tuesday	7.15-8.00 8.00-8.45 15.30-17.00	general specific	gymnastics Individual technique, attack, defence, throws, counter-attack	in a group and individually in a group and individually
Wednesday	7.15-8.00 8.00-8.45	specific	Individual technique, attack, defence, throws	in a group and individually
Thursday	7.15-8.00 16.45-18.15	oriented specific	Development of general and specific fitness components Counter-attack, attack defence	in a group and individually In a group
Friday	13.40-14.25 14.25-15.20	specific	Individual technique, attack, defence, throws	in a group and individually
Satursay, Sunday	competition			

Workload during the third year of training

During the third year of training cycle (the last year of middle school), the number of training sessions was similar to that of the previous year. The loads were oriented to technique and tactic development as well as specific fitness improvement of the handball players.

Tab.7. *The example of a one-week training microcycle of the handball players from the sports class of the Middle School in Reszel during the third year of training.*

Day of a week	Time of training	Type of training	Content	Organization
Monday	13.40-14.25 14.25-15.20	general general	gymnastics general fitness	in a group in a group
Tuesday	8.00- 8.45 8.50-9.35 15.30-17.00	oriented specific	general and specific strength Individual technique, attack, defence, throws, counter-attack	Individually and in a group Individually and in a group
Wednesday	7.15-8.00 8.00-8.45	specific	attack, defence, throws, counter-attack	Individually and in a group
Thursday	7.15-8.00 18.15-19.45	oriented specific	Development of general and specific fitness components Control game	Individually and in a group in a group
Friday	13.40-14.25 14.25-15.20	specific	Individual technique, attack, defence	Individually and in a group
Satursay, Sunday	competition			

Discussion and Conclusion

The aim of the study was to investigate the effect of applied training loads in 13-15 years old female handball players within the three-year training cycle. The study revealed statistically significant differences between the values of physical fitness and capacity indexes. This could be caused by the two factors: training load and biological maturation. While the later is obvious, the first, in terms of the amount and type of load, could influence the relevant adaptive changes and the improvement of performance. The current results align with those of Cardinale [2002], Czerwiński and Jastrzębski [2003] or Jastrzębski [2004], who state that the optimal volume and type of training load could be crucial for the development of physical capacity and fitness of the male and female handball players.

The studies on training effects should have practical application, especially when conducted for several years. The examples of training microcycles in the consecutive years presented in the work can serve as a model for other teams operating within middle school sports classes system.

Table 4 shows that the studied subjects performed 284 and 286 training sessions during the second and third year respectively. That makes about 210 hours of effective exercise a year. This volume is similar to that of female professionals. Therefore, it is crucial to apply them rationally in order to avoid sustained fatigue.

In conclusion, the significant improvement of physical capacity and fitness suggests that the training load applied to the female handball players within the three-year training cycle was correct and corresponding with their maturation status.

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DIFFERENCES IN LOAD IN GIRLS AGED 10 TO 12 YEARS IN PLAYING HANDBALL WITH VARIOUS TYPES OF DEFENSES

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Summary
We try to determine the level of load to which the female players aged between 10 and 12 years were exposed while playing handball with three different game forms. Eleven subjects played nine model games. As an indicator of load we use the number of occurrence of 15 parameters/playing elements. SPSS statistical packege was used for statistical analysis. Results show that statistically significant differences do exist in the following variables: "length of the attack", "number of assists«, "number of goals", "number of shots", "number of technical errors", "number of attacks", “number of jump shots from 9 meters” and “number of jump shots from 6 meters”.

Keywords
Handball, youth female, game forms, playing load.

Introduction
In the methodology of teaching and training individual sports games new models are increasingly appearing, which basically retain the characteristics of the primary sport game, but are modified in a way that gives young players more satisfaction while learning and playing. For the same reason handball experts designed a game called “Mini Handball (a game with modified rules). The need to adapt the rules of handball for younger players in Slovenia was first mentioned in 1971 (Pavčič, & Vidic, 1971. Generally, mini handball is played by children of age up to 10, after that they transfer to playing handball on the entire court, as it is determined in the official rules. There are however difficulties when transferring from mini handball to the entire court which are mostly connected to the larger number of players in the game and the bigger space. The basic element for playing handball is the ability to find room for oneself or a teammate. Because handball is a dynamic sport, the space is inseparably linked with time. The distribution of space on the court is constantly changing and the players must be capable to recognise the current situation, to anticipate the subsequent development and react as suitable as possible (Landgraf, & Denne, 2001). Children at that age are physically (morphological size and motoric capabilities) and psychologically (sensing of problematic situations in the game, their processing and appropriate reaction) not mature enough to play handball over the entire court surface. They also lack the necessary knowledge. The big amount of teammates with which the individual should cooperate and the number of adversaries that are hindering them are also a problem. On behalf of data mentioned above it is clear that a suitable systematic solution (way of playing) must be found, so that players of that age are enabled to play on the entire surface of the court. An important contribution to solving this problem is the game 2 x 3 vs. 3, which Landgraf was the first to describe in his contribution (Landgraf, 1997). Later on authors described the meaning of this game in more detail and stated possible varieties or methodical completions, which make the basic game even more practical and interesting (Denne, 2001; Landgraf, & Denne, 2001; Feldman, 2003). In praxis there remain two other modes of play – a game with a man marking defence and a game with zone defence across the entire court. On the basis of what is written in the introduction, the purpose of this study is to compare the strain to which the players are exposed during matches which are played in three different models of defences (Man-to-man

defence, Zone defence or 2 x 3 vs. 3 game form). The players were girls aged 10 to 12. Based on these differences in levels of load, we tried to assess the suitability of different game-play modes.

Methods

Sample

The subjects were 11 female handball players aged between 10 and 12 years, members of female handball club Celje. At the time of measurement, the study subjects were 10.7±0.86 years old on average. Their average body height was 153.5±9.5 cm and body mass 47.8±7.25 kg.

Methodology

Experimental procedures

The main part of the experiment consisted of nine model matches with three different game forms. This part of study was conducted over a 3-week period, with all experimental sessions scheduled at the same time of the day (on Monday, Tuesday and Thursday). At the beginning of each experimental session, players performed a standardized 20-minute warm-up protocol. Matches were always played by the same teams (with regard to composition of the players) and according to the handball rules. Rules were slightly adapted to the needs of experiment: duration of matches lasted 2 x 10 minutes, players replacement were not allowed, "team time-out" was not allowed, all the matches were played between 5 and 8 pm. Matches were recorded by the camera positioned on one side of the court. Footage was analysed to count the number of occurrence of 15 parameters/elements.

Table 1: *Schedule of matches through the three-week experimental cycle*

Day	1. week	2. week	3. week
Monday	Man-to-man defence	Zone defence	Game 2 x 3 vs. 3
Tuesday	Game 2 x 3 vs. 3	Man-to-man defence	Zone defence
Thursday	Zone defence	Game 2 x 3 vs. 3	Man-to-man defence

Variables

In sample of variables 15 parameters/playing elements were included: average duration of attacks, number of passes, number of goals, number of shots, number of technical errors, number of feints, number of sprints, number of 7-m caused, number of free-throws, number of goalkeepers saves, number of attacks, number of shots from 6-metres – ground shots, number of shots from 9-metres – ground shots, number of shots from 6-metres – jump shots, number of shots from 9-metres – jump shots.

Statistical data analysis

The SPSS statistical package (IBM SPSS 20.0) was used for statistical data analyses. Descriptive statistics for the variables were computed with its fundamental measures of central tendency and dispersive parameters. Shapiro - Wilk test was used to verify normality of distribution. The differences in parameters among all three game modes were established by one-way analyses of variance (ANOVA) and Brown-Forsythe's test which is nonparametric alternative for one-way ANOVA. To determine the differences between the individual game modes, a series of post-hoc Tukey's test were applied.

Results

Table 2 presents the basic statistical characteristics of selected parameters for all three modes of playing. The table shows average values, minimum and maximum values.

Table 2: *Basic statistical characteristics of all parameters for all three game forms*

Parameter	Zone defence			Man-to-man			2 x 3 vs. 3		
	$\bar{x}$	min	max	$\bar{x}$	min	max	$\bar{x}$	min	max
Average duration of attacks (sec.)	22,6	20,8	24,9	14,3	13,8	14,9	14,1	12,4	15,1
No. of passes	366,6	344	389	240,3	237	245	199,7	187	219
No. of goals	21	19	23	37,6	33	44	32,3	29	34
No. of shots	44,3	43	46	55,6	52	59	48	43	51
No. of technical errors	8,3	6	11	27,7	24	33	34	30	40
No. of feints	4,3	2	7	1,7	1	3	2,3	2	3
No. of sprints	2	1	3	10,7	6	14	10,7	4	17
No. of 7-m caused	6,7	2	11	3,3	2	6	2,7	2	4
No. of free-throws	16	15	17	16	12	23	17,3	17	18
No. of goalkeepers saves	13,3	12	15	11	9	13	11,7	7	17
No. of attacks	51,3	47	55	79,7	77	83	79,3	74	89
No. of shots 6-metres–ground shots	10,3	6	14	7,7	2	13	6	4	8
No. of shots 9-metres–ground shots	1,3	0	4	1,3	0	4	0,7	0	2
No. of shots 6-metres–jump shots	21	17	26	46	40	55	41	39	44
No. of shots 9-metres–jump shots	11,6	9	16	0,7	0	2	0,3	0	1

In Table 3 the significance of Shapiro – Wilk's test for variables distribution normality are presented.

Table 3: *Significance of Shapiro-Wilk's test for all three game forms*

Parameter	Sig. Shapiro-Wilk test		
	Zone defence	Man-to-man	2 x 3 vs. 3
Average duration of attacks	,628	,739	,116
Number of passes	,975	,463	,339
Number of goals	1,000	,510	,000**
Number of shots	,637	,843	,220
Number of technical errors	,780	,407	,363
Number of feints	,780	,000**	,000**
Number of sprints	1,000	,463	,915
Number of 7-m caused	,878	,000**	,000**
Number of free-throws	1,000	,157	,000**
Number of goalkeepers saves	,637	1,000	,780
Number of attacks	,726	,637	,114
Number of shots from 6-metres–ground shots	,726	,900	1,000
Number of shots from 9-metres–ground shots	,000**	,000**	,000**
Number of shots from 6-metres–jump shots	,637	,363	,363
Number of shots from 9-metres–jump shots	,253	,000**	,000**

"**" Differences significant at $p<0.01$

From Table 3 is evidently that data of some parameters are not normal distributed. By the zone defence such parameter is only one: »Number of shots from 9-metres–ground shots«, by man-to-man defence data were not normal distributed at »Number of feints«, »Number of 7-m caused«, »Number of shots from 9-metres–ground shots« in »Number of shots from 9-metres–jump shots«. By the 2 x 3 vs. 3 game form such parameters are following »Number of goals«, »Number of feints«, »Number of 7-m caused«, »Number of free-throws«, »Number of shots from 9-metres–ground shots« in »Number of shots from 9-metres–jump shots«.

For parameters with normal data distribution one-way Analyses of variance (ANOVA) was applied to determine whether any significance differences exist among all three game modes.

Table 4: *Results of one-way analysis of variance (ANOVA)*

	F	Sig.
Average duration of attacks	31,253	,001**
Number of passes	83,954	,000**
Number of shots	8,941	,016*
Number of technical errors	28,394	,001**
Number of sprints	3,714	,089
Number of goalkeepers saves	,411	,681
Number of attacks	24,795	,001**
Number of shots from 6 meter – ground shots	,849	,474
Number of shots from 6 meter – jump shots	17,308	,003**

"*" Differences significant at $p<0.05$

"**" Differences significant at $p<0.01$

To determine differences between the groups for the parameters where the assumption of data distribution normality was not fulfilled, instead of ANOVA the Brown-Forsythe test was applied.

Table 5: *Results of Brown-Forsythe test*

	Statistic	Sig.
Number of goals	14,597	,020*
Number of feints	2,167	,260
Number of 7-m caused	1,531	,339
Number of free-throws	,139	,877
Number of shots from 9 meter – ground shots	,111	,897
Number of shots from 9 meter – jump shots	23,396	,025*

"*" Differences significant at $p<0.05$

In order to determine individual differences among all three game forms a series of Tukey's Post hoc test were applied. Results are presented in Table 6.

Table 6: *Results of Tukey's Post hoc test*

Variable	Game form	Game form	Sig. Tukey's test
Average duration of attacks[a]	Zone defence	Man-to-man	,001**
		Game 2 x 3 vs. 3	,001**
	Man-to-man	Game 2 x 3 vs. 3	,983
Number of passes[b]	Zone defence	Man-to-man	,000**
		Game 2 x 3 vs. 3	,000**
	Man-to-man	Game 2 x 3 vs. 3	,053
Number of goals[c]	Zone defence	Man-to-man	,004**
		Game 2 x 3 vs. 3	,026*
	Man-to-man	Game 2 x 3 vs. 3	,283
Number of shots[d]	Zone defence	Man-to-man	,014*
		Game 2 x 3 vs. 3	,426
	Man-to-man	Game 2 x 3 vs. 3	,070
Number of technical errors[e]	Zone defence	Man-to-man	,004**
		Game 2 x 3 vs. 3	,001**
	Man-to-man	Game 2 x 3 vs. 3	,252
Number of attacks[f]	Zone defence	Man-to-man	,002**
		Game 2 x 3 vs. 3	,002**
	Man-to-man	Game 2 x 3 vs. 3	,997
Number of shots from 6 meter – jump shots[g]	Zone defence	Man-to-man	,003**
		Game 2 x 3 vs. 3	,010**
	Man-to-man	Game 2 x 3 vs. 3	,542
Number of shots from 9 meter – jump shots[h]	Zone defence	Man-to-man	,003**
		Game 2 x 3 vs. 3	,002**
	Man-to-man	Game 2 x 3 vs. 3	,983

"*" Differences significant at p<0.05
"**" Differences significant at p<0.01
[a] Man-to-man and 2 x 3 vs. 3<Zone defence; [b] Man-to-man and 2 x 3 vs. 3<Zone defence; [c] Man-to-man and 2 x 3 vs. 3>Zone defence; [d] Man-to-man>Zone defence; [e] Man-to-man and 2 x 3 vs. 3>Zone defence; [f] Man-to-man and 2 x 3 vs. 3>Zone defence; [g] Man-to-man and 2 x 3 vs. 3>Zone defence; [h] Man-to-man and 2 x 3 vs. 3<Zone defence.

Discussion and Conclusions

The most important findings that stem from the data gained are the following: at the game with man-to-man defence as well as at 2 x 3 vs. 3 game there were significant differences in the average values in comparison with games with zone defence regarding the following variables: "duration of the attack", "amount of passes", "number of goals", "number of technical fouls", "number of attacks", "number of shots from jumps from 6 m", "number of shots from jumps from 9 m". There were no distinctive differences in the mentioned parameters at games with individual defence and 2 x 3 vs. 3 games. There were also no significant differences at all the other parameters between all three games. The different number of elements carried out during the game itself speaks in favour of the fact that games that are played in different ways differentiate from one another. The attacks when using zone defence were longer, which means that the game was slower and less dynamic. There was also a large amount of passes; because the attackers were less hindered and did not lose the ball so often (that is also the reason for the difference in number of technical fouls). The large number of jumps from the distance of 9 meters at games with zone defence is reasonable and is a consequence of the zone formation 6:0, where the defence is more shallow and dense, for that reason the players do not come that close to the goalkeepers space. In comparison with other types of playing the reliability of shots was consequentially lower when playing zone defence. The players at this age are namely physically not strong enough to shoot effectively from greater distances. The game with man-to-man defence and the 2 x 3 vs. 3 game are quite different from the zone way of playing but they are similar in the number of carried out elements. The length of the attack in average is lower in both ways of playing because a faster game more often leads to a possibility for a shot or a technical foul. The average amount of passes is also lower. Even though we want the players at handball to pass as often as possible, in our case this means that the game was more passive because of a greater amount of passes. The players were running less and their attacking activities were not directed towards the goal. One of the main goals of handball is to achieve as many goals as possible. We found that this goal is reached when playing with man-to-man defence and in mode 2 x 3 vs. 3. In games that were played in this way the average amount of goals was high, in comparison with the zone way of playing the efficiency of shots was also a lot better. Games with man-to-man defence and 2 x 3 vs. 3 are faster and more dynamic, that is why there are also more technical fouls. One of the reasons for that is that the players are running more and faster, which presents a bigger strain. This leads to less focus when passing and in other technical elements. At games with man-to-man defence and at the 2 x 3 vs. 3 games there was a similar average amount of attacks which was distinctively larger than when playing in zones. This data also speaks in favour of the fact that these two ways of playing are faster and that the attack and defence are exchanged more often. Considering the stated it is necessary to give priority to man-to-man defence and not zone defence when the players belong in younger age categories. It is definitely also important to introduce zone defence at this age - especially the open defence system. In this way they get to know different playing positions which are typical for attacks against zone defence and the location where they function. Doing this it is important to focus on executing activities which the children already know from playing individual defence (individual elements like running, dribbling - specifically for different playing positions). It is however not yet meaningful to introduce team combinations in attacks (team tactics) and complex cooperation of defence players in the meaning of helping the defence player next to you. A combination of all three ways of playing therefore makes sense. This gives the children better chance to gain knowledge of handball and develop different abilities.

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CHARACTERISTICS OF EFFORT IN PLAYING HANDBALL WITH DIFFERENT TYPES OF DEFENSES IN GIRLS AGED 10 TO 12 YEARS

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Summary
We try to determine the level of effort to which the female players aged between 10 and 12 years were exposed while playing handball with three different game forms. Eleven subjects played nine model games. As an indicator of effort we use the hart-rate. SPSS statistical packege was used for statistical analysis. There were significant differences between measured heart-rates during games using individual defence and 2 x 3 vs. 3 game form comparing to those games playing with zone defence. But there were no significant differences between games with individual defence and 2 x 3 vs. 3 game form.

Keywords
Female handball, youth handball, game forms, heart-rate.

Introduction

In the methodology of teaching and training individual sports games new models are increasingly appearing, which basically retain the characteristics of the primary sport game, but are modified in a way that gives young players more satisfaction while learning and playing. For the same reason handball experts designed a game called "Mini Handball (a game with modified rules). The need to adapt the rules of handball for younger players in Slovenia was first mentioned in 1971 (Pavčič, & Vidic, 1971. Generally, Mini handball is played by children of age up to 10, after that they transfer to playing handball on the entire court, as it is determined in the official rules. There are however difficulties when transferring from Mini handball to the entire court which are mostly connected to the larger number of players in the game and the bigger space. The basic element for playing handball is the ability to find room for oneself or a teammate. Because handball is a dynamic sport, the space is inseparably linked with time. The distribution of space on the court is constantly changing and the players must be capable to recognise the current situation, to anticipate the subsequent development and react as suitable as possible (Landgraf, & Denne, 2001). Children at that age are physically (morphological size and motoric capabilities) and psychologically (sensing of problematic situations in the game, their processing and appropriate reaction) not mature enough to play handball over the entire court surface. They also lack the necessary knowledge. The big amount of teammates with which the individual should cooperate and the number of adversaries that are hindering them are also a problem. On behalf of data mentioned above it is clear that a suitable systematic solution (way of playing) must be found, so that players of that age are enabled to play on the entire surface of the court. An important contribution to solving this problem is the game 2 x 3 vs. 3, which Landgraf was the first to describe in his contribution (Landgraf, 1997). Later on authors described the meaning of this game in more detail and stated possible varieties or methodical completions, which make the basic game even more practical and interesting (Denne, 2001; Landgraf, & Denne, 2001; Feldman, 2003). In praxis there remain two other modes of play – a game with a man marking defence and a game with zone defence across the entire court. On the basis of what is written in the introduction, the purpose of this study is to compare the strain to which the players are exposed during matches which are played in three different models of defences (Man-to-man defence, Zone defence or 2 x 3 vs. 3 game form). The players were girls aged 10 to 12. Based on these differences in levels of strain, we tried to assess the suitability of different game-play modes.

Methods

Sample

The subjects were 11 female handball players aged between 10 and 12 years, members of female handball club Celje. At the time of measurement, the study subjects were 10.7±0.86 years old on average. Their average body height was 153.5±9.5 cm and body mass 47.8±7.25 kg.

Methodology

Experimental procedures

At the begging of the experiment subjects performed an intermittent fitness test "30-15$_{IFT}$" on a handball court – 30 s of running and 15 s of rest (Buchheit, 2005a; Buchheit, 2005b). The subjects were running at a pace dictated by a sound signal. The running speed increased with each repetition and the runners persevered until exhaustion or so long as they were capable of running the specific distance foreseen in the interval.

The subjects wore heart rate monitors - Polar Team2 Pro. In this way we got the data about the maximum heart rate. To obtain data about values of the heart rate at rest, subjects were instructed to individually measure the frequency of heartbeat every morning for five consecutive days. The frequency of the heart rate is measured on a neck artery with the help of subjects' parents. From all five measurements we have calculated the average frequency of heart rate at rest for each subject separately. Karvonen model was used to calculate relative heart rate frequency, which is based on the calculation of heart reserve (HR % = 100 X (HR ─ HRrest)/(HRmax ─ HRrest).

The main part of the experiment consisted of nine model matches with three different game forms. This part of study was conducted over a 3-week period (Table 1), with all experimental sessions scheduled at the same time of the day (on Monday, Tuesday and Thursday). At the beginning of each experimental session, players performed a standardized 20-minute warm-up protocol. Matches were always played by the same teams (with regard to composition of the players) and according to the handball rules.

Rules were slightly adapted to the needs of experiment: duration of matches lasted 2 x 10 minutes, players replacement were not allowed, "team time-out" was not allowed, all the matches were played between 5 and 8 pm.

Table 1: *Schedule of matches through the three-week experimental cycle*

Day	1. week	2. week	3. week
Monday	Man-to-man defence	Zone defence	Game 2 x 3 vs. 3
Tuesday	Game 2 x 3 vs. 3	Man-to-man defence	Zone defence
Thursday	Zone defence	Game 2 x 3 vs. 3	Man-to-man defence

Variables

Sample of variables are presented in the table below. All measurements were conducted by the same people, using the same measurement technology.

Table2: *Sample of variables*

Parameter	Measured capacity	Measuring unit
HR_rest	Heart rate frequency at rest	beats/min
HR_max	Maximum heart rate frequency	beats/min
HR_abs	Absolute HR values during the games	beats/min
HR_rel	Relative HR values during the games	%

Statistical data analysis

The data were analysed using the statistical package SPSS 20.0. Basic parameters of the distribution of variables were calculated. Mauchly test was used to verify normality of distribution. We also calculated the Huynh-Feldt test as a correlation factor, because the analysis of variance for repeated measurement would not be calculated correctly without it. To find individual differences between different types of playing, we also carried out the so called "Post-hoc analysis". We were studying differences for the first and the second half separately, as well as for the entire game.

Results

First heart rate frequency at rest and maximum heart rate frequency data are presented.

Table 3: *Heart rate frequency at rest and maximum heart rate frequency for each subject*

Subject	HR_rest	HR_max
1	69	210
2	68	200
3	70	220
4	66	210
5	65	204
6	72	211
7	58	209
8	68	207
9	70	207
10	77	212
11	75	203

Table 4: *Average values of heart frequencies in different types of the game by half-times and for the entire match*

	Man-to-man defence	Zone defence	2 x 3 vs. 3
1. half	177 beats/min	169 beats/min	175 beats/min
2. half	180 beats/min	166 beats/min	173 beats/min
Entire match	178 beats/min	168 beats/min	174 beats/min

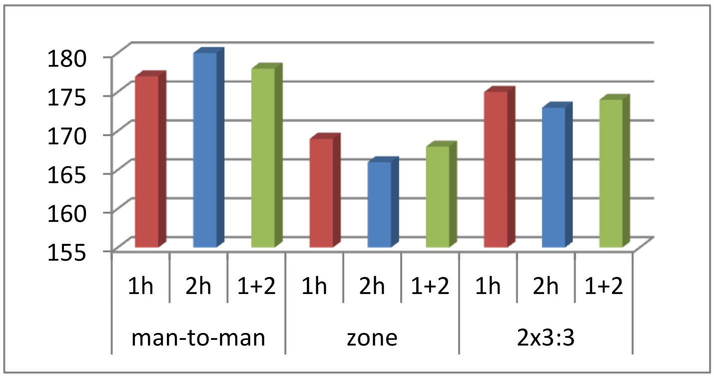

Figure 1: *Graphical presentation of average values of abosolut heart frequencies in different types of the game by half-times and for the entire match.*

In the table (Table 4) and the graphical presentation (Figure 1) we can see that the players measured achieved the highest heart rate frequency at a game with man-to-man defence. During the first half-time their average heartbeat frequency was 177 beats/minute (b/m), in the second half-time 180 b/m and in average through the entire game 178 b/m. The lowest values were measured at a game of zone defence, where their average heartbeat frequency was 169 b/m in the first half-time, 166 b/m in the second and 168 b/m in average. It turns out that the 2 x 3 vs. 3 game is in between these two types concerning heartbeat frequency. During the first half-time their average heartbeat frequency was 175 beats/minute (b/m), in the second half-time 173 b/m and in average through the entire game 174 b/m.

Hereinafter we are presenting the relative heartbeat frequencies which individually take into consideration the minimal and maximum heartbeat rates of every player measured individually. The average relative values are presented in per cent of the maximum, divided by type of defence game and additionally by both half-times and the entire game.

Table 5: *Relative HR values during the games expressed in percent from maximum*

	Man-to-man defence	Zone defence	2 x 3 vs. 3
1. half	78%	72%	76%
2. half	81%	70%	75%
Entire match	79%	71%	75%

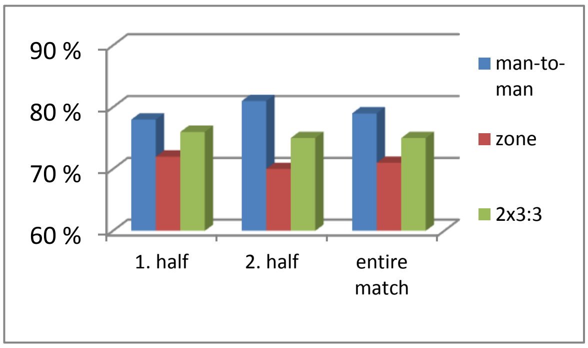

Figure 2: Relative HR values during the games expressed in percent from maximum.

Before we carried out the analysis of statistically significant differences in relative values of the HR between different types of playing we were studying the normality of data division with the Mauchly test, with the help of which we tried to check the spherics. We found that this presumption is violated in the second half-time, which is why spherics is not valid (Table 6).

Table 6: *Significance of Mauchly's test for variables distribution normality*

	Mauchly 's W	Approx. Chi-Squa.	Df	Sig.	Epsi.		
					Green.-Geisser	Huynh-Feldt	Lower-bound
1.half	,952	,444	2	,801	,954	1,000	,500
2.half	,469	6,810	2	,033	,653	,712	,500
Entire match	,659	3,747	2	,154	,746	,847	,500

The above mentioned finds have led us to also calculating the Huynh-Feldt test as a correlation factor; because the ANOVA is not calculated correctly without it for measurements which are repeated (the results are too low). We chose this test because the value epsilon was higher than 0.75.

Table 7: *Significance of Huynh-Feldt test*

	Coeficient	df	F	sig.
1.half	Huynh-Feldt	2,00	12,94	0,000
2.half	Huynh-Feldt	1,42	14,06	0,001
Entire match	Huynh-Feldt	1,69	15,70	0,000

The results of the Huynh-Feldt test point out differences between the frequency of the relative heart rate when playing in individual styles of defence. For this reason we also carried out the so called "Post-Hoc analysis", with the help of which we researched individual differences between different styles of playing.

Table 8: *Differences in HR_rel. achieved in the matches played with man-to-man defence and zone defence*

	Game mode	df	F	sig.
1.half	man-to-man defence : zone defence	1	19,929	0,001
2.half	man-to-man defence : zone defence	1	22,507	0,001
Entire match	man-to-man defence : zone defence	1	23,232	0,001

From Table 8 is evidently that statistical significant differences do exist for every half-time period separately and for the entire match as well. During the matches played with man-to-man defence higher HR_rel. were achieved than during the matches played with zone defence.

Table 9: *Differences in HR_rel. achieved in the matches played with zone defence and 2 x 3 vs. 3 game form*

	Game mode	df	F	sig.
1.half	zone defence : 2 x 3 vs. 3	1	13,170	0,004
2.half	zone defence : 2 x 3 vs. 3	1	25,878	0,000
Entire match	zone defence : 2 x 3 vs. 3	1	24,170	0,001

Also in the relationship between the matches played with a zone defense and the matches played with 2 x 3 vs. 3 game form, specific differences appear separately for individual half-time as well as for the entire match. Higher values were achieved in 2 x 3 vs. 3 game mode.

Table 10: *Differences in HR_rel. achieved in the matches played with man-to-man defence and 2 x 3 vs. 3 game form*

	Game mode	df	F	sig.
1.half	man-to-man defence : 2 x 3 vs. 3	1	1,901	0,198
2.half	man-to-man defence : 2 x 3 vs. 3	1	4,594	0,058
Entire match	man-to-man defence : 2 x 3 vs. 3	1	4,657	0,056

We couldn’t prove any significant differences in HR_rel. achieved during the matches played with man-to-man defence and 2 x 3 vs. 3 game mode.

Discussion and Conclusions

The most important findings that stem from the data gained are the following: at the game with man-to-man defence as well as at 2 x 3 vs. 3 there were distinctively higher average

HR_rel. values than by a game with zone defence. The HR_rel. values do not differentiate that much between a game with man-to-man defence and a 2 x 3 vs. 3 game. The findings are valid for both separate half-times as well as for the whole game. From the point of view of strain assessed with HR_rel., playing handball for girls of the age of 10 to 12 is more exhausting when playing man-to-man defence and a 2 x 3 vs. 3 game than when playing a game with zone defence. On the basis of the findings we can state that a game with man-to-man defence and a 2 x 3 vs. 3 game stimulate the development of motory and functional skills at a higher degree. In both cases a man-to-man type of defence is used, but the game is played in intervals at 2 x 3 vs. 3 game type - it is played alternating on the one and the other side of the court. When playing the type with man-to-man defence the game is played on the entire court surface for all players. A large part of usage of both models of playing in relation to goals and realisation of these is in practice dependant on the creativity of the individual trainer. This most of all concerns the adaptation of rules concerning duration of the game, number of participating players, breaks between individual parts of the game, type of player exchange, evaluation of goals, etc. The dynamics of the game is increased in both cases, which is according to our opinion the biggest advantage in comparison to zone defence, when transferring from mini handball, where there are fewer players (four players and the goalkeeper), to handball played across the entire court (six players and the goalkeeper). The game includes short-term high intensity strains as well as more or less active breaks. A short-term high intensity strain (up to 10 seconds) must namely be followed by a long active or passive break, so that the exhausted stock of ATP and creatine can be refilled with the help of aerobic energy processes. The problem of playing handball with zone defence is that the level of development of certain abilities and technical-tactical knowledge of the children of this age is not on a level high enough to allow the performance of complex elements of a handball game and of team manoeuvres, which are necessary to attack this kind of defence (Šibila, 2004). A game that demands too many such actions from them often becomes uninteresting and not dynamic.

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DIFFERENT TRAINING PERIODIZATION MODELS IN FEMALE HANDBALL

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Summary
The aim of this study was to identify the periodization model that allows greater improvement in the most important handball performance factors in a Spanish first league women's handball team.

Keywords
Traditional training periodization, Block periodization, performance

Introduction
Training periodization is the strategy to promote long-term training and performance improvements with pre-planned, systematic variations in training specificity, intensity, and volume organized in periods or cycles within an overall program. The basis of contemporary training theory were founded a few decades ago by Matveyev (1964) and Ozolin (1973) when knowledge was far from complete and workload levels, athletic results and competitions demands were much lower than nowadays. Traditional training periodization (TP) was proposed at that time and became a universal approach to training planning. Further sport progress emphasized the limitations and drawbacks of TP with regard to the preparation of contemporary top-level athletes and their demands. Major contradictions between traditional theory and practice needs appeared, such as 1) an inability to provide multi peak performances during the season; 2) the drawbacks of long lasting mixed training programs; 3) negative interactions of non-compatible workloads that induced conflicting training responses; and 4) insufficient training stimuli to help highly qualified athletes to progress, as a result of mixed training. The trials and successful experiences of prominent coaches and researchers led to alternative training concepts and, ultimately, to a reformed training approach that was called block periodization (BP). Its general idea suggests the use and sequencing of specialized mesocycle-blocks, where highly concentrated training workloads are focused on a minimal number of motor and technical abilities. Unlike traditional periodization, which usually tries to develop many abilities simultaneously, the block concept suggests consecutive training stimulation of carefully selected fitness components. The rational sequencing of specialized mesocycle-blocks presupposes the exploitation and superimposition of residual training effects, an idea that has recently been conceptualized and studied. It is hypothesized that different types of mesocycle-blocks are suitable to various modes of biological adaptation, i.e. homeostatic regulation or a mechanism of general adaptation (Issurin, 2008).

The aim of this study is to find out which of the two training periodization models results in greater improvement of the most important physical and conditional handball performance factors.

Methods
Nine senior female players which played two consecutive seasons in a Spanish first division team took part in this study. All subjects were part of a team with an average of 12 hours of

training per week (age 21.9±5.1, height 168.8±7.2, weight 64.4±5.3 at the start of the study). All players received verbal and written information about the study and gave informed written consent before anthropometric and conditional assessment.

During the first part of the season (August to December) and for two consecutive seasons, training was carried out following the two periodization models. During the first season, training was carried out following TP model, and during the second season, training was carried out following BP model. At the beginning and final of the two periods, different test were carried out to measure handball key performance variables.

Table 1. Chronological schedule of Periodization models and tests application.

First week August first season	August-November	Last week November first season	First week August second season	August-November	Last week November second season
Test 1	TP model	Test 2	Test 3	BP model	Test 4

The test protocol was divided in two groups (anthropometric and fitness characteristics), and was carried out in two different sessions (morning and afternoon).

Table 2. Chronological schedule of the test protocol application

Morning	Afternoon
Anthropometry test Vertical jump test Maximal isometric hand grip force test	Throwing velocity test VO2 max. test

Anthropometry

Anthropometric measurements were taken according to standardized procedures by an ISAK (International Society for the Advancement of Kinanthropometry) certified anthropometrist (Stewart, Marfell-Jones, Olds and Ridden, 2011). Dimensions included height, body mass, arm span, arm length and forearm length, three skinfolds (triceps, front thigh and medial calf), six breadths (biacromial, biepicondylar-humerus, biepicondylar, biiliocristal, bitrochanteric and bistyloid), ten girths (arm relaxed, arm flexed and tensed, forearm, wrist, chest, waist, gluteal, thigh, calf and ankle).

Height and weight measurements were made on a set of scales (Seca, Barcelona, Spain) with an accuracy of 0.01 kg and 0.001 m, respectively. Skinfolds were measured with a Harpenden Calliper. The girths were measured using a Lufkin metal tape (Lufkin Executive Thinline, W606PM, USA). The breadths and lengths were measured using an anthropometer (GPM, Siber Hegner, Zurich, Switzerland) with an accuracy of 0.01 cm.

Several variables were found: a) the body mass index (BMI) was calculated as weight (kg) divided by height (m^2), b) fat free mass (FFM) (%) using the method described by Lee (Lee et al, 2000).

Throwing velocity test

Throwing velocity was assessed with a radar gun (StalkerPro Inc., Plano, TX, USA), with 100 Hz frequency of record and with 0.045 $m\cdot s^{-1}$ sensitivity, placed behind the goal post and in a perpendicular direction to the player. This test has been shown to have very good test-retest reliability, with an intraclass correlation coefficient (ICC) of 0.96, and a coefficient of variation (CV) of 2.4%.

Prior to the throwing velocity test, subjects performed a 15 min warm up focused on overhead throwing. The subjects performed two different protocols of throw, one with a goalkeeper and one without. For both protocols, subjects threw a standard handball as fast as possible towards a standard goal, using a single hand and their personal technique. The sequence of throwing was: a throw from just behind the 7 m penalty mark, a throw from just behind the 9 m line, a three-step running throw from the 9 m line and a three-step running throw from the 9 m line with a jump. Three throws of each type were performed and the best trial was used for further analysis.

Only throws sent to the goal post were used for analysis. For motivational purposes, players were immediately informed of their performance. A 3-minute rest elapsed between throws in order to avoid fatigue.

Maximal isometric hand grip force test
The grip strength of dominant hand was measured using a standard adjustable digital hand-grip dynamometer (T.K.K. 5401, Tokyo, Japan) with a sensitivity of 10 N. Anthropometric equipment and hand-grip dynamometer were calibrated before each assessment. All subjects were tested after 3 minutes of independent warm-up. The players performed 2 repetitions at maximum intensity. The best trial was used for further analysis. Three minutes rest elapsed between trials in order to minimise the effects of fatigue. This test presents an ICC of 0.95 and a CV of 4.9%.

Vertical jump test
Each subject performed two kinds of maximal jumps (Squat jump (SJ) and Countermovement jump (CMJ)) on a Jump Mat (Ergo Jump Bosco System Byomedics, SCP, Barcelona, Spain). The subjects completed 3 attempts of each type of jump, and the best one was used for the subsequent statistical analysis. For motivational purposes, players were immediately informed of their performance. Between jumps, the subjects were allowed to recover for three minutes to avoid fatigue. Jump height was calculated using flight time. In a previous pilot study performed with part of these subjects, the test-retest ICC and the CV were 0.94 and 3.6%, respectively. The CMJ and the SJ showed an ICC of 0.93 and a CV of 4.2%.

Maximum Oxygen Uptake test
(VO_{2max}) was determined during an incremental maximal intensity test on a calibrated treadmill. The following test protocol was used: The initial velocity was set at 2.4 m/s and increased to 2.8 m/s after 5 min, the inclination of the treadmill was 1 %. After another 5 min of warming-up at this speed, inclination was increased to 2 %, and velocity was increased by 0.2 m/s every 30 sec until exhaustion.

Standard statistical methods were used to calculate the mean and standard deviations. T-test for related samples was used to analyse the improvement of the different handball key performance factors. The $p \leq 0.05$ criterion was used for establishing statistical significance.

Development
Descriptive statistics of anthropometric and fitness characteristics are shown in Table 3.

In the present study, improvements in anthropometric and fitness characteristic in two different seasons were compared. For the first training periodization model, improvements have only occurred in two variables: percentage of muscle mass (Muscle Mass %) and 7 m. throw with goalkeeper (7m + GK). For the second model, improvements have occurred in variables concerning the explosive force: SJ, CMJ and different kinds of throws.

Table 3. Mean and standard deviations values ($\bar{x} \pm sd$) correspondent to anthropometric and fitness characteristics of the players

Variables	Sig	Test 1	Test 2	Test 3	Test 4
Body composition					
Body mass (Kg)		64.4±5.3	64.6±5.0	64.2±5.4	64.0±4.6
BMI (%)		22.6±1.7	22.5±1.9	22.4±1.4	22.5±1.7
Muscle Mass (%)	a*	43.2±6.3	45.4±5.4	37.6±2.6	33.9±15.6
Fitness Characteristics					
SJ (cm)	b*	23.8±3.5	23.6±4.1	25.7±4.6	28.0±4.2
CMJ (cm)	b**	26.4±4.0	27.0±3.6	27.8±5.3	30.4±4.3
Isometric Hand Grip (N)		39.3±3.8	37.2±5.1	38.2±5.4	36.8±4.3
VO_{2max} (ml/kg/min)		53.8±5.8	55.0±6.6	46.9±4.9	47.2±4.4
Throwing velocity (Km/h)					
7m		70.0±7.6	69.7±8.4	61.2±2.6	65.7±5.6
7m + GK	a*	70.4±6.8	72.0±6.6	63.0±2.9	63.5±5.8
9m	b*	70.6±7.8	69.6±7.8	60.2±3.4	67.5±7.0
9m + GK		71.6±6.8	69.9±8.0	61.3±4.9	66.4±7.2
9m 3Steps	b*	73.0±7.0	69.9±8.0	65.2±4.6	69.0±5.3
9m 3 Steps + GK		72.8±4.5	71.6±4.9	66.3±4.7	69.7±5.3
9m Jump		69.2±4.0	67.6±3.8	64.3±2.4	66.6±4.6
9m Jump + GK		68.8±4.3	69.3±4.2	65.7±2.4	69.2±3.0

Legend: *a= significant differences between test 1 and test 2; b= significant differences between test 3 y 4. (*) by p<0.05; (**) by p<0.001.*

In addition to the shown significant differences, we founded a tendency to the significance between test 3 and 4 in two more kinds of throwing: 7 m. ($p<0.058$) without goalkeeper and 9 m. with 3 steps and goalkeeper ($p<0.069$). It is deduced as a result of different studies (Chelly et al., 2010; Wallace and Cardinale, 1997; Manchado et al., 2013) that the physical prevailing requirements of handball are the explosive force in the upper and lower limbs (player movement's velocity, jump capacity and throwing velocity of the ball) and the maximal force and muscular power (required in contact moves against the opponents).

Although both methods (TP and BP) produce performance improvements, the second (BP) seems to be preferable. With the BP, the improvements achieved between August and December are significant for variables considered key performance factors in Handball like explosive strength and throwing velocity (Vila et al., 2012; Granados et al., 2007). Considering that the sample used in this study is rather small, it would be necessary to replicate the study with a larger sample in order to confirm the results presented here.

Conclusions

With the development of training and the modifications in the structure of present competitions, the way in which the coaches structure the workloads has to be adapted to their needs. The identification of the periodization model that allows greater efficiency and applicability is necessary. Results show that with a BP model more significant improvements are achieved than with a TP model. For this handball team was more convenient to use the BP than TP model.

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PERFORMANCE ANALYSIS. A WAY TO IMPROVE COACHING METHODS IN HANDBALL

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Summary
Monitoring and analysing performance is an integral part of everyday sporting life. In team sports particularly, it is very important to recognise successes and failures and analyse them in relation to a preset team plan or tactic. At major international handball events, there is the availability of the official match statistics which satisfies the needs of the coaches from match to match. However, it is necessary for every coach to draw up a match statistic sheet which is tailored to suit a team's needs and also functions as a useful coaching tool.

The aim of my study is to enhance performance analyses by designing a match statistics sheet which includes as much information as possible and collecting documentary evidence about the regularity of the most important technical-tactical elements at a handball match. In order to achieve these objectives I used a number of matches from the 10th Women's European Handball Championship 2012 in Serbia, as the field of testing for observing and collating data on the spot.

The results showed that data collated and formatted systematically provides an excellent opportunity for various analyses. Apart from categories that are traditionally used, I introduced others which add more detail to the analysis. I found that this type of performance analysis is a practical tool used to continually enhance the team's overall performance.

Keywords
Performance indicators, match statistics, collating data, analysis, bench marks

Introduction
Constantly monitoring and analysing performance is an integral part of everyday life as an instrument for enhancing achievement. In sport generally, it is very important to recognise successes and failures and analyse them in relation to a preset team plan or tactic. In team sports particularly, where performance thus success is made up of several elements, it is difficult to take note of and recall all the important episodes of the game.

As part of their job, teachers and coaches are experts at observing events and performances yet are unable to commit everything to memory. In their studies about coaches observing and remembering key performance factors, Franks and Miller (1986 and 1991) concluded that no matter how well trained in observation coaches were, generally they were only able to recall 30% to 50 % of what they had witnessed. (Franks and Miller 1986 and 1991) However, it is obvious that a thorough analysis based on systematic and accurate observation is a fundamental instrument for enhancing performance.

Coaching process
"The coaching process is about enhancing performance by providing feedback about the performance to the athlete or team." (Hughes, M. 2005-2013) Since human memory is limited and the coach's opinion is often emotional and biased, the use of measuring and recording tools is necessary to support the feedback process. Data for movement analysis, technical -

tactical evaluation or for statistical purposes can be compiled by hand and/or through a computerised notation system. Both these systems are used either independently or together and both have advantages and disadvantages.

A more traditional form of collating data either during a match or after it from a recording, the *hand notation system* is generally very accurate. However, to present the data to the coach and athletes meaningfully is time consuming and storing the information is impractical. A more modern form of collating data, the *computerised notation system* on the other hand solves this problem by recording and storing data simultaneously. It can convert data into a graphical or pictorial form to make it easier for players and coach to understand and at the same time it adds to the data base. Unfortunately operator, hardware or software errors might occur in this system and are difficult to correct particularly in real-time recording. Therefore, it is crucial to have an experienced operator to enter the data quickly and correctly.

No matter which notation system coaches prefer, two main factors must not be neglected: the analysis must be objective and systematic. Objectivity can be achieved through a careful and neutral notation system. While a well established coaching process provides a systematic framework for performance analysis.

The coaching process is cyclical – it starts and ends with PERFORMANCE as the main objective is to always improve. In order to make the process more manageable, it is best to break it down into smaller elements.

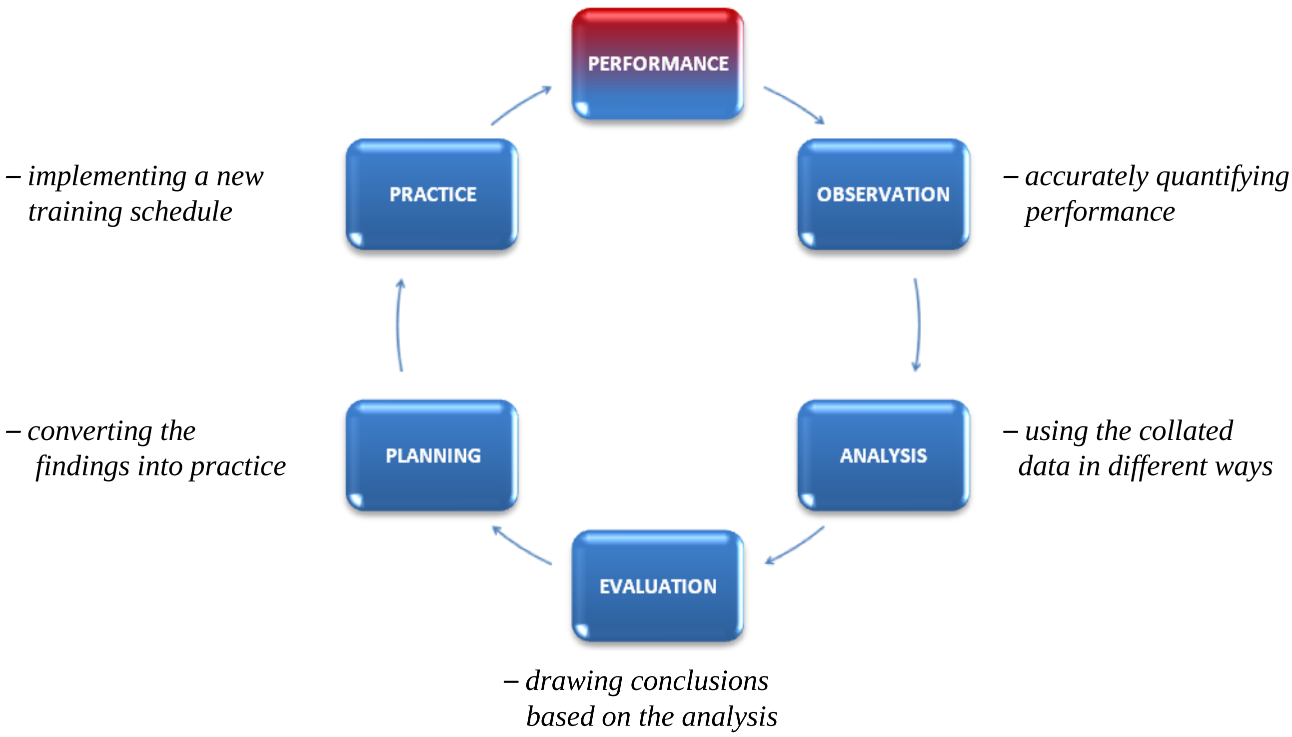

Fig.1. Coaching process

A well designed coaching process ensures that the performance analysis is carried out in an organised, systematic and cohesive manner, with respect to the teaching-learning scheme.

Objective

The main aim of my study is to enhance performance analyses by designing a match statistics sheet which includes as much information as possible and can be easily filled in/completed. Secondly, to collect documentary evidence about the regularity of the most important areas of attack and defence at a handball match, in order to provide data for further studies.

Methods

In order to achieve this main objective I used a number of matches from the 10^{th} Women's European Handball Championship 2012 in Serbia, as the field of testing for collating data on the spot.

As part of their practical course requirements, a group of Hungarian students from the ICEC level III Coaching Course was given the task to observe, collate data and annotate the preliminary matches of Group C in Novi Sad. Each student had to make at least one match analysis as part of their group and also to collect individual data on at least one playing position. The 30 coaches involved all had previous experience in collecting data and doing match analyses as they are presently all active coaches. In order to have a uniform and standardised notation system, I designed a template with set criteria and I pre-trained them beforehand in order to ensure accuracy in the notation system. My aim was also to design a system that is self explanatory, easy to summarise onto one sheet, to computerise and evaluate.

Such a large group of observers allowed me to divide them into groups for match analysis (4-6 observers / match / team). We used a manual notation system during the matches then transferred the data into an Excel table after the event. This method of processing data proved to be practical as I was able to take advantage of both manual and computerised notation systems.

Match statistics

The main reason for compiling match statistics is to get an overall picture of the match through recorded evidence of what happened for further analysis. Visual information seen on court is converted to tangible statistics on paper and thus, in this way numbers can be analysed statistically so that conclusions can be drawn based on factual evidence.
When designing a match statistics template, the following should be taken into consideration:

- The aim of statistics is not to record everything but rather to record only the relevant facts, therefore it should be done in combination with the official match report. Thus, it is not necessary to include all the elements that are already recorded in the match report; rather it should be used as a valid support document.

- Every coach should ideally design his/her own statistical form according to his/her own needs, yet all match analyses should include the characteristic handball specific categories such as goalshooting efficiency, saving ratio, errors, assists and so on.
- Match statistics can be completed on the spot, during the match or after the event from a recording. However, one observer/operator can record only one team's activity at a time. During a game, experience or more man power is needed to be precise while from a recording it is easier to be accurate as there is always the possibility to rewind, re-watch and check.

- To maintain objectivity, the match statistics should reflect the referees' decision not personal opinion. However, personal opinion/subjectivity can be discussed when analysing match performance with the team. (For example, a statistical symbol may suggest that a player has made an error but in light of the match circumstances it may have been acceptable.)

- It is more practical to do match statistics manually on a prepared template and then convert it to the electronic version. However, with good computer skills an observer can recorder the data directly into a computerised template. (For example, copying/pasting the symbols directly into the Excel template.)

Designing a Statistical Template
The set up of the template sheet is very important because it needs to facilitate easy recording of as much information as possible and allow for easy analysis later on.

For ease of recording,

- it is practical to use A4 paper horizontally because of the many categories needed;
- the key to the symbols used should always be displayed on the same page;
- the symbols used for notations should be simple and easy to draw;
- the two halves of the match should be marked with different colours.

Analytical Categories
The two basic units of attack and defence can be further sub-divided into smaller categories (key performance indicators) such as goalshooting, assists, errors (in attack) and blocking, stealing, individual errors (in defence) for cross comparison thus analysis. Therefore, it is important to define and clarify each category to avoid misconceptions.

Development
Following the Coaching Process model, the next step is to work out how to analyse the data collated through observation. As mentioned, it is practical to transfer the data directly at the match or indirectly from the observation sheet into an Excel table because the system allows for quick and accurate mathematical calculations.

Analysing the data – Match Statistics
The Match Statistics table was designed in such a way that it is possible to analyse the data both horizontally and vertically.

- The **horizontal analysis** describes each player's <u>individual performance</u> by going through the statistical categories from *left to right*.

- The **vertical analysis** describes the <u>team's performance</u> by adding up the individual performance of the players from *top to bottom*.

In **Goalshooting** by calculating the *shooting/saving efficiency* ratio in each position (e.g. 2 goals / 3 attempts from pivot position), then working out the sum of them as the total efficiency (e.g. 13 / 19) indicates the players' effectiveness in the concluding phase of the attack. The advantage of this marking system is that the symbols don't just show whether there is a goal or not, rather it shows why the shot is unsuccessful (e.g. missed, blocked, post etc.), giving the analyst a fuller picture. The order of symbols within each section shows the sequence of shots at the goal, while the different colours denote the shots made in the different halves. With the help of this marking system, a player's goalshooting progress can be tracked to give a full picture of his performance throughout the match. (Table 1)

MATCH STATISTICS		GOALSHOOTING						
No.	Name	Fast B.	Break-T.	Through-S.	Wing S.	Pivot S.	7 M sh/s	Goal or Save / Shot
14	NORMAN Gordon	● ● ⊗ ●	● ⊗ ● ●	⊗ ● ● ⊗ ⊗ ●	●	● ⦸ ●	●	13 / 19
21	GROSS Andreas	●		⊗ ● ● ●	● ⊗ ●			6 / 8

Table 1. *Goalshooting performance*

In the first two categories of the **Attack Activity** section the players' positive actions are recorded: *earned 7m penalty - throw* and *assists* given to the team mates. They are also important indicators regarding the players' involvement in attack organisation/ setting up scoring positions. While in the other categories the marks specify the areas where the players lose possession of the ball as a result of *step* mistakes, *line* infringements, *lost ball* or *causing an attacker's foul*. These are considered to be negative actions. A "*negative foul*" signifies that although the attacker does not lose possession of the ball, he/she is stopped by the defender with checking. This slows and breaks down the attack organisation and thus is not advantageous for the attackers. (Table 2)

MATCH STATISTICS		ATTACK Activity						
No.	Name	7 M earn	Assist	S.P.	L.N.	L.B.	c. A.F.	negative FOUL
14	NORMAN Gordon	x x	x / x x / x x		x	x x / x x /		x / x / x / x / x
21	GROSS Andreas	x	x /	x		x	x	x / x

Table 2. *Attack activity*

Defence activity starts with "*positive foul*", so that the two categories are next to each other for ease of comparison. Since it is advantageous for a defender to stop an attacker, this move is considered to be a positive action. The next categories, *blocking* a goalshot, *stealing* the ball by intercepting a pass or snatching it out from an attacker's hand as well as *earning an attacker's foul* are also considered positive actions for the defender. While *individual error* is an identifiable and obvious mistake, a negative action of the defender. (Table 3)

MATCH STATISTICS		DEFENCE Activity				
No.	Name	positive FOUL	BL.	ST.	e. A.F.	I.E.
14	NORMAN Gordon	x /	x	x x /		/ x x
21	GROSS Andreas	x x		x	x	x x / x x

Table 3. *Defence activity*

Table 4. *Completed Match statistics*

Place: **Novi Sad, SRB** | Date: **04. 12. 2012**

● - goal | ○ - missed | ■ 1st half | ■ 2nd half | ⊗ - saved | ⦸ - post / bar | ⊙ - blocked | NP - not played

x = assist or error and goal | / = assist or error and no goal

Teams: **CRO** vs **HUN** ECh | Final score: **28:27** (15:14)

MATCH STATISTICS		GOALSHOOTING							ATTACK Activity						DEFENCE Activity					
No.	Name	Fast B.	Break-T.	Through-S.	Wing S.	Pivot S.	7 M sh/sa	7 M earn	Assist	S.P.	L.N.	L.B.	c. A.F.	negative FOUL	positive FOUL	BL.	ST.	e. A.F.	I.E.	Goal or Save / Shot
12	HERR Orsolya (GK)	● ● ● ⊗ ●	● ● ● ● ● ● ●	⊗ ● ● ⊗ ⊗ ●	● ●	● ● ●	● ●					/								4 / 25
21	KISS Éva (GK)	●		⊗ ● ● ●	● ● ●															1 / 8
6	VÉRTEN Orsolya		⊗ ●		⊗ ⊗ ⊗					/	/	x		/ / / / / / /	/				x x x	1 / 5
7	SZUCSÁNSZKI Zita		● ⊗	⊗			⊗		x x			x x	/	/ /	/ / / / / /		x x	/		1 / 4
11	SZABÓ Valéria													/	/ / /	/			x /	0
13	GÖRBICZ Anita		●	● ⊗ ⊗		●	● ● ● ⊗ ● ●	x x	x x x x x x x	/		x / / x x x	/	/ / / / / / / / /	/ / /		x / x	/	/ x x	8 / 11
15	KLIVINYI Kinga		●																	1 / 1
18	SZAMORÁNSKY Piroska	● ⊗				⊗		x x			/			/ / / / / / /	/ / /	/	x	x x	x x x	1 / 3
20	RÉDEI-SOÓS Viktória		● ● ⊗	⦸ ● ⊗ ⊗	⊗			x x	x	/		x x	x	/ / / /	/ /		/		x x x x	3 / 8
22	BÓDI Bernadett										/		/	/ /		/				0
23	SZEKERES Klára														/ / / / /	/ /	x		/ x x	0
83	KOVACSICZ Mónika	● ●		⊗	●			x	x x	/		x		/ / / /	/ / /		x		x x x x x	3 / 4
87	TOMORI Zsuzsanna		● ● ●	● ● ● ⊗ ⊗ ⊗ ● ● ● ⊗								x /	/	/ / / / / / / / / / / /	/ / / / /	x /	x	x /	/ x x x x x	9 / 13
	Goal / Shot - Total	3/4	9/12	8/19	1/5	1/2	5/7	7	12	4	5	14	5	48	29	6	10	6	29	27 / 49 55%

Key of Symbols: F.B.= Fast break, B.T.= Break-through, T.S.= Through-shot, W.S.= Wing shot, P.S.= Pivot shot, 7M = Penalty-throw, sh/sa = shot/saved, AS.= Assist, S.P.= Steps, L.N.= Line, L.B.= Lost Ball, c.A.F. = causing an attacker's fault, negative FO.= stopped by a defender in attack, positive FO = stops an attacker in defence, BL= Blocking, ST = Steal, e.A.F = earning an attacker's fault, I.E.= Individual Error

The “ / ” symbol signifies an assist or an error but when crossed “ X ” it also represents the consequence of the action – a goal, giving further information to the observer.

Conclusions

After the data has been collected and collated, what can be gained from analysing and evaluating this information? How can a coach use this material to plan training exercises and put them into practice?

During this study, my main aim was to design a match statistics sheet which includes as much information as possible and can be easily completed. As previously mentioned match statistics provide a comprehensive overview of any given match and this data can be used to characterise the performance of both the individual and the team. Apart from the traditionally used categories (e.g. shooting / saving ratio, assists, errors), I introduced other categories which further help to make the analysis more detailed. For example, *earning* either a *penalty* or an ‘*attacker’s foul’* demonstrates the player’s positive involvement in attack and in defence respectively. Whereas, causing an *attacker’s foul* or making an *individual error* count as mistakes in attack or in defence. Establishing the categories of ‘*positive’* and ‘*negative’ fouls* give further information about the player’s attacking and defending behaviour (e.g. marks in the section ‘positive foul’ means that the player in defence stops the attacker with the ball by checking and this is a positive remark, whereas if the player in attack is stopped by a defender and marked as a ‘negative foul’ then this is not a good indication of his playing attitude in attack). My experience, based on many matches analysed in this way, is that most of the time the team that has more marks in the section of ‘positive faults’ (stopping the attacker with ball by checking) wins the game. I also applied a new marking system: although the *goalshooting symbols* are the same for court players and goalkeepers, the interpretation of the results is different (for example, “save” is not good from the court players’ perspective but means success for the goalkeeper). Using the ‘/’ symbol signifies an assist or an error but when crossed ‘X’ it also represents the consequence of the action – a goal. The summary of the horizontal and vertical analyses of the data provides the opportunity to compare this data to the pre-established key performance indicators. In this way bench marks can be set for either the individual and /or the team for future performance.

As can be seen from this study, if the data is collated in an organised way and evaluated systematically, the conclusions drawn can facilitate performance analysis. All this information can be and should be converted into the practical work of the coach. In order to take full advantage of this information, the coach devises training sessions based on the weaknesses and strengths of his /her team derived from his/her analysis. This type of performance analysis is a practical tool used to continually enhance the team’s overall performance.

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DIFFERENCES BETWEEN THE WINNING AND DEFEATED FEMALE HANDBALL TEAMS IN RELATION TO THE TYPE AND DURATION OF ATTACKS

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Summary
From the video-records of the matches of the 2010 European Women's Handball Championships in Denmark and Norway 2710 attacks were extracted for the analysis. The sample of variables contains: attack type and duration of attacks. The aim of the research was to determine the difference between the winning and defeated teams according to the observed variables.

Keywords
Structural analysis, performance (situational efficiency), notation analysis, handball games, stage attacks

Introduction
A complex system of handball game represents the integration of elements in handball techniques and tactics as well as their application in competitive conditions according to the rules. Diversity and a large number of active participants (players), semi active participants (referees, coaches, coaching staff) and passive participants (spectators) generate the progress of game, marked with characteristic sequences (phases) that interchange in different time periods on different space segments of handball court.

Handball match is a system in which alternate game's state interchange and they are divided into attack phase and defence phase. If those two main phases are observed in context of stability of the court, it can be said that the phase of defence has a stabilizing function while attack phase has destabilizing function (Vuleta and Gruić, 2004). The conversion between these states (transition) is an inactive for performance in attack or defence. Depending on the way of execution, and finalization, sequence of actions in the transition phase, defines the structure of the defence and attack phase. Attack in team handball can be viewed as makroevent or decomposed segment of a match consisting of a series of events (Rogulj, 2009). The attack phase of the game is a situation in which one team possesses the ball. Begins at the moment in which a team gains a property of the ball, and lasts as long as the ball is not lost. The aim of the attack is to achieve a goal by deliberate actions (Šimenc, Pavlin and Vuleta, 1998).

This study was conducted to determine which registered values of the observed variables and to what extent (types of attacks and duration of attacks) contribute to situational efficiency in team handball, i.e. to determine the difference between the winning and the defeated teams at the Championship on the basis of the observed variables.

Methods

Sample of entities in this study is 2710 attacks registered in the European Women's Handball Championship 2010 in Denmark and Norway. For description of the entities (attacks) variables *types of attack* and the *duration of the attack* were used. Variable type of attacks is divided into three categories, namely three modalities: position, transition, and other attacks. Situational interaction of opposing players i.e. the connection between attacks and defence of the opposing team (Rogulj, 2003) is taken into the consideration in the classification of types of attacks which means the transition attacks (counter-attacks) imply an attack on an unorganized defence, and positional attacks imply an attack on organized defence. In the other group (specific) attacks there are all those attacks which by all their performance characteristics do not belong to any of the above types of attacks. Duration of attacks is defined as time in which a team is in phase of attack according to the rules of handball.

Data were collected from video records of Women's European Handball Championship 2010 in Denmark and Norway, which were available at the official internet EHF (European Handball Federation) website http://www.ehf-euro.com/Stream.2860.0.html #. Specially designed software that allows online statistical and video analysis of games of different sports (football, basketball, water polo) made a specific modality adjusted to team handball. For the purposes of this research into the programme defined variables have been introduced (tagged), videos were attached from games of championship, and after they were analysed individual entities or attacks were extracted. To each "sliced" attack the corresponding values or a defined set of variables were attributed. Each variable was uniquely defined.

In accordance with set objectives and metric characteristics of the variables appropriate parametric and non-parametric statistical methods were applied. Descriptive analysis of nominal variable of types of attacks was made by grouping multi-dimensional data. The data obtained are presented by contingency tables. At the same time, they are presented graphically in 3D bivariate frequency histograms and stacked graphs column and rows vertical orientation. Basic descriptive parameters (the number of entities, the arithmetic mean, minimum value, maximum value and standard deviation) were calculated for a quantitative continuous variable (duration of attack). To determine the difference between nominal variables χ^2 - test for two or more independent samples was applied. The χ^2 - test was used to determine the statistical significance differences between successful and unsuccessful teams by type of attack. Kruskal -Wallis test and univariate analysis of variance (ANOVA) were used to test the difference between a winning and defeated team according to the variable duration of attacks.

Results and Discussion

Out of the total of 2710 attacks played, the winning team played a total of 1356 attacks, and defeated only two attacks less i.e. 1354 attacks. Recorded numerically almost identical frequencies of attacks played for the winning and defeated teams have a different structure according to the basic types of attacks (position, transition, others). Winning teams have played a total of 1057 positional attacks (PN), 236 transitional (TN) and 65 other attacks (ON). Defeated teams have played a total of 1115 positional attacks, then 177 transition and 62 other attacks.

Table 1. *Frequency of different types of attacks for the winning and defeated teams (observed, by columns, by rows)*

	observed frequency			columns %		rows %	
Type of Attacks	**WIN**	**DEF**	**Total**	**WIN**	**DEF**	**WIN**	**DEF**
PN	1057	1115	2172	77,95%	82,35%	48,66%	51,34%
TN	236	177	413	17,40%	13,07%	57,14%	42,86%
ON	63	62	125	4,65%	4,58%	50,40%	49,60%
Total	1356	1354	2710				

PN- positional attacks, TN- transitional attacks; ON- other attacks ; WIN- winning teams; DEF- defeated teams

χ^2=9,98, df=2, p=0,01;

The calculated value of χ^2 - test (χ^2 = 9.98) suggests that the winning and the defeated teams significantly statistical differ with respect to the type of attack.

Registered ratio of structural units of handball game i.e. attacks (two attacks more for winning) indicates approximately equal conditions for success, with approximately the same number of situations that allow a change of match results. Insight into the structure of these attacks (Table 1) allows explaining the statistically significant differences of performance through positional and transitional states of handball game. Detailed insight into the obtained differences allows graphics of structure of particular attacks according recorded frequencies for successful and unsuccessful teams (Figure 1, 2, 3).

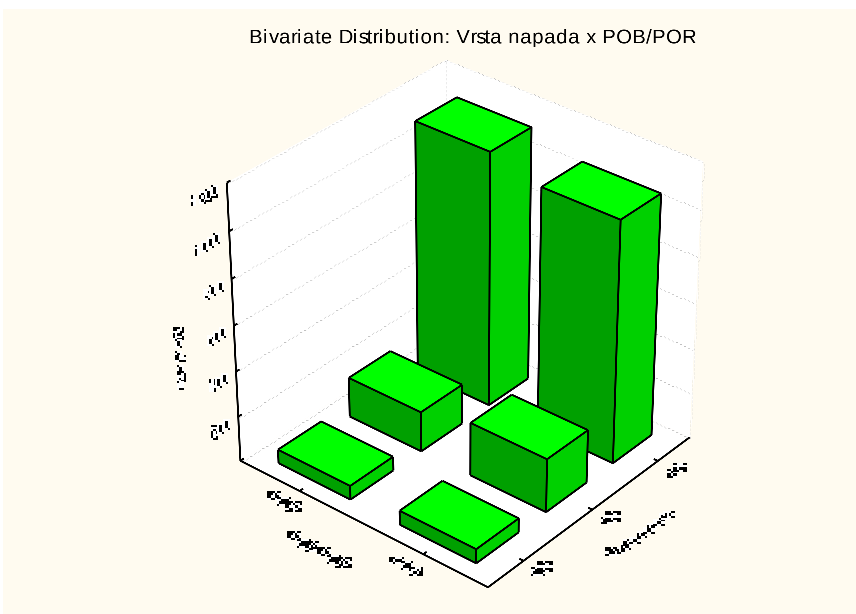

Figure 1. *Structure of attacks types for wining and defeated teams*

Figure 2 shows that the overall structure of the attack winning team defined by 77.95% positional attacks, 17.40% transition attack and 4.65% of other attacks, while the structure of the attack defeated team is defined by 82.35% positional attacks, 13.07% transition attack and 4.85% of other attacks.

Previous studies indicate a significantly larger number of positional than the transition attacks (Skarabalius, 2011; Šibila et al., 2011). The above mentioned also reveals that the most common segments of handball match, observed in confrontation of two teams (teams in defence / teams in attack), took place on set and organized defence (usually zonal or combined), and on the other hand organized and set game in the positional attack. Both teams used elements of individual techniques (different ways of shooting performance, fints with or without the ball, etc.), then the elements of group tactics (stabbing, double passes, different modes of exchange places ("cross") to/from the ball blocks, runs, etc.) combinations involving all players (individual, group and collective technical and tactical elements of handball game) have built and implemented positional attacks.

4.4% more of previously described positional attacks were recorded in the overall structure type of attack for defeated team in relation to the winning team. The ratio of transition attack (attack) in the overall structure of the basic types of attacks successful and unsuccessful teams indicates a greater prevalence (4.33% increases) for the winning team. Other attacks participate in defining the overall structure of the attack for winning and the defeated team with equal share.

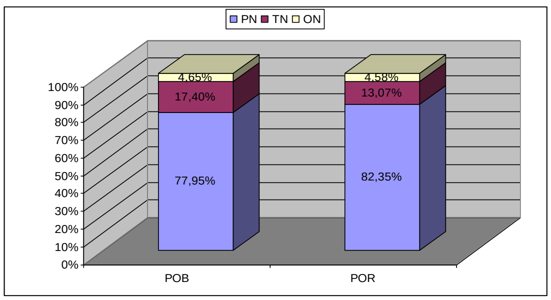

Figure 2. *Type of attacks-WIN/DEF*

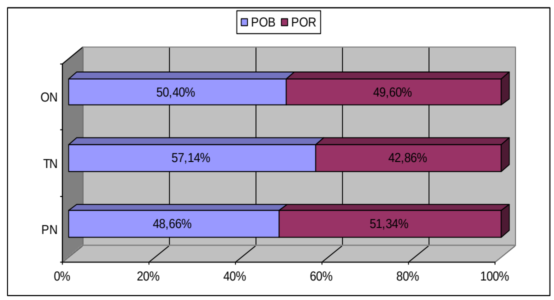

Figure 3. *WIN/DEF – Type of attacks*

The structure of certain types of attacks (positioning, transition, and others) and their classification with regard to the implementation of successful and unsuccessful teams (Figure 3) indicates that the winning team performed 48.66%, and defeated 51.34% of the total positioning attacks. The transition attacks in winning (57.14%) and a defeated (42.86%) teams reveals the greatest difference between them. Namely, the winning team carried out a 15.28% more transition attacks than the defeated team in relation to the total number of transition attack (counter-attacks). The significance of the attack on the unorganized defence as reliable indicators of the successful performance is recognized in a number of studies (Rogulj, 2003 to Kovač and Đukic (1980), Tukić (1983), Praznik (1991); Gruić, 2006; Hianik, 2008). Other attacks are nearly identical to both successfully applied different teams. In the implementation of individual, group or collective counter-attack action the biggest difference recorded in the application of the same in the wining and the defeated teams. The winning teams turned potential situations in the transition state of the handball game into transition attacks with the higher frequency of the performance than the defeated teams.

Table 2 presents the basic statistical parameters: mean, minimum and maximum values and standard deviation for the variable duration of the attack separately for the winning and defeated teams.

Table 2. *Descriptive statistic (duration of the attack -WIN/DEF)*

WIN/DEF	Duration of the attack				
	N	AS	Min	Max	Std.Dev.
WIN	1356	23,43	1,00	80,00	14,05
DEF	1354	23,33	1,00	81,00	13,69
TOTAL	2710	23,38	1,00	81,00	13,87

Results of Kruskal-Wallis test and analysis of variance indicated that there is no statistically significant difference in the duration of attacks between the wining and the defeated teams.

Table 3. *Kruskal-Wallis test and Analysis of variance*

Duration of the attack			
H=0,00	p=0,06 p=0,96	F=0,04	p=0,85

Uniformity in duration of attacks for winning and defeated teams can be explained by different quantities of the types of attacks. Namely, as the winning teams had more transition attacks than defeated teams with average slightly shorter duration and longer construction attacks i.e. longer positional attacks, there was a compensation by which average total duration of attack assumes similar number values for winning and defeated teams (Table 4).

Table 4. *Duration of positional and transition attacks (WIN/DEF)*

	positional attacks		transition attacks	
	N	duration	N	duration
WIN	1057	27,65	236	7,34
DEF	1115	26,32	177	7,38

Total differences between successful and unsuccessful teams stem from differences in the number of transition attacks that are based on: the efficiency of creating conditions for transition attacks and maintenance of initially created advantages that classified the attack as transition (disorganized opposing defence and created a numerical and spatial advantage in relation to the opposing team). In relation to the variable duration of the attack there were no statistically significant differences between successful and unsuccessful teams, and the possible reasons are that defeated teams failed to make the transition potential attacks and such attacks often ended up as position attacks, and thus the duration of the attack in winning and the defeated teams was approximately the same.

Conclusions

This research is an attempt to clarify the situational efficiency in team handball, by analyzing the frequencies and values of the observed variables in relation to success, i.e. to establish the characteristics of successful and unsuccessful teams.

The performance efficiency observed by differences between winning and defeated teams shows that the application of a number of transitional attacks (57.14% and 42.86% winning/defeated teams) contributes to success of teams in competition. Researching the structure of team handball game well as defining factors of situational efficiency is burdened by a number of limiting factors, especially by technical complexity of the analysis of competitive conditions and by the determination of players' anthropological features which makes it difficult to determine its exact values (Rogulj, 2003).

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DEFENSIVE SYSTEM 3:3: INTRODUCTION TO DEFENSE IN ZONE

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Summmary
This article deals with the early experiences of the so-called zonal defences open in Spain, to later define the characteristics of the 3:3 zonal defensive system[1], and the denomination of the players in the different specific positions.

The central part offers a "Decalogue", explaining the different roles that players must know, learn and work. Some individual roles, the defender of the player with the ball and the defender of the player without the ball. Other groupal roles, in order to coordinate the work between the defenders, and, finally, a collective role. It ends highlighting the importance that tactical means of help and coverage have in this defensive system.

Keywords
Team handball, defence in zone, introduction to defence in zone

Introduction
The first time we saw a 3:3 zonal defensive system with a lot of distance between lines, with players taking on a lot of profundity, was the Spanish Junior Women's National Team, preparing their qualification for the 1995 World Championship in Brazil, the coach of that team was the Spanish coach Carlos Colmenero Rubio (Colmenero, 1995). Accustomed to zonal defences with little profundity, we have to confess that, for us, it was quite a shock.

Before developing this proposal 3:3 zonal defence, we would like to note that, in our opinion, and in line with other authors, as Alonso (1983), Oliver and Sosa (1996), García-Herrero (1998, 2003) etc., the open zonal defences are essential in the teaching-learning process of children at the base. Why? In general, nowadays no one disputes the need that in the early contacts with handball, in the first matches, teams must use an individually defensive system over the whole playing field, and subsequently, just in one half of the own playing field.

But, how do we must move from an individually defence to a zonal defence? In our opinion, the answer is with an open defence in two lines, the 3:3 zonal defensive system we are going to present here, because it allows us to explain to the players, and put in practice in an easy way, -among other things- the concept of zonal defence, and on this basis, changes of opponents-adversaries, basis of zonal defensive systems. However, we would also like to note that this is no a defensive system just for the beginners, because with it we can assure that several teams have achieved success in different categories, included teams of top sports performance.

This article presents a proposal of executing a 3:3 zonal defence, which of course is not the only, but it is what we have practiced a few years ago with the Cadet and Junior Women's

[1] This proposal was exposed for the first time on 27 July 2006 during the "V National Meeting o Handball´s Teachers of Brazilian Higher Education Institutions" held in Aracaju (Sergipe) Brazil, organized by Brazilian Handball Confederation (Oliver, 2006).

Selections of Andalusia, Brazilian women's National Team, and nowadays the Spanish youth women´s National Team, among other teams.

Characteristics

Our proposed 3:3 zonal defensive system has the following characteristics:

- *A zonal defence:*
  Players defend an area delimited by their coach in profundity and width. Therefore, as a rule, if occur the abandonment of the specific playing position, by an attacker, either by movements of wings or by any first line player (left back, right back or center back), the defender will accompany the attacker, and when they crossing, there will be a corresponding change of opponent, keeping each defenders, their initial defensive zone.
- *A defence of "help":*
  Players must learn to perform the collective tactical means named "coverage" and "help", and reach to domain its. In this kind of open defences the errors have an easy solution through helps. We must also begin to think that, as well as we leave the specific position when we are in attack, we also can likewise leave to the specific position in denfense. It is therefore a defence of helps, a "joint defence".
- *"Offensive" Defence:*
  The proposal allows also work the collective defensive tactical means, -using the terminology of Antón (2002), such as defending the odd, flotation or two against one. But above all, the philosophy of this model is to prevent tactical organization of the opponent team, not let them play ordered, shortening the decision time, getting that they are always uncomfortable, pressured, etc.

Distribution of players

- *Initial spatial distribution of the players in the 3:3 zonal defensive system*
  Figure 1 reflects the zonal distribution of the defenders in this defensive system, and on the left, the name of each specific position, according to the classical designation of specific position in zonal defensive systems.

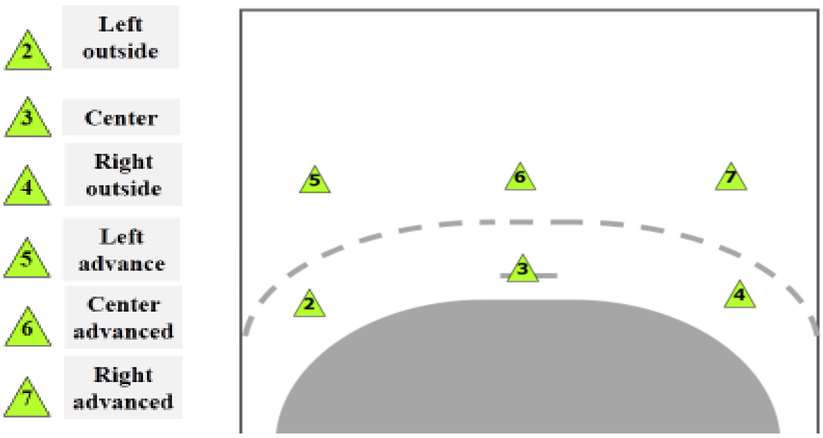


Figure 1. Graphic Representation of 3:3 zonal defensive system.

Proposal work: "the decalogue"

The aim of this work is to explain how to teach and train through 10 steps or decalogue, the approach, philosophy and functioning of this zonal defence 3:3 open, with profundity.
Player must learn and perfect 10 functions:

- 7 Individual Responsibilities:
  - ✓ When defends to a player who has the ball (4 responsibilities)
  - ✓ When defending the player who hasn't the ball (4 responsibilities)
- 2 Groupal Responsibilities
- 1 Collective responsibility

<u>*Individual responsibilities*</u>

We refer to those responsibilities which the player must follow and which does not need any coordination with their teammates. This not mean that each of defenders acting on their own. The idea is that everyone must do its share of work from the perspective of individually technique-tactic.

- *A) Defender of the player with the ball.*

(1). Do not go towards the opponent

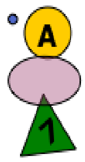
The defender will not go ever towards an opponent with the ball, this circumstance would be with the attacker steps cycle intact and would have much advantage, multiplying **the danger of his feint of displacement and commit disciplinary sanctions**.

Wait until the attacker with ball use the three steps and need to bounce the ball.

(2). On the bounce, harass!

Once the attacker with ball begins to bounce must harass **in order to stop bouncing and take or adapt the ball.**
So, the attacker only can perform three steps to complete the cycle of steps.

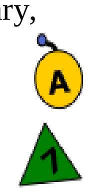
(3). Harassing without technique fault.



Once the player with the ball has used its cycle of steps (3-step + bounce (s) + 3-step) the defending player shall harass without committing any technique fault.
The idea is to get that the attacker with ball make a mistake, as offensive fault, steps, bad pass, etc.

(4). Assess the dangerous of the opponent.

The defender must assess the dangerousness of his opponent with ball. This is primarily determined by two or three parameters.
The first is the orientation to the goal, while more vertical, more dangerous, on the contrary, while more orientation towards the sidelines, less dangerous.



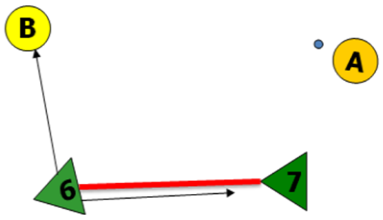
The second is the arm position and head. Arm prepared to throw, danger, if the arm is not armed the danger decreased. Regarding the head, if it is up, looking straight ahead with wide visual field, maximum risk, if instead the opponent is looking down with a small visual field, the risk is greatly reduced.
The third parameter would be the distance to the goal. The more distance, the less danger of effectiveness in the throwing.
We have to "educate" the defenders learn to appreciate the danger of the opponent with the ball, according terms of these instruction, because, with maximum danger may commit a fault, but if there is no dangerous, to commit a fault would be an important error, as this would let the opposing team could reorganize.

- *B) Defender of the player without the ball*

(4). Assess the dangerous of the opponent

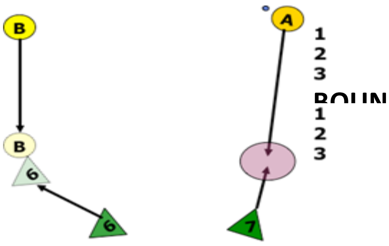
All above is also valid for the player whose opponent doesn't have ball possession, applying the logical adaptations.
The good use of individual tactic, will let lead the opponent to positions and situations of limited danger.

- *(5). Half way*



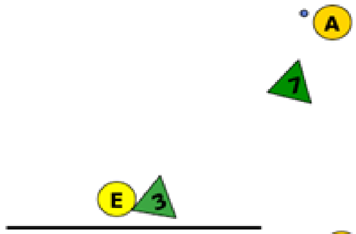
The defender (6) of the player without the ball (B) shall be placed in a situation of "coverage" to make a help to his teammate (7) if it is necessary, and also to get to defend his direct opponent (B), if he gets the ball.
That is, should be placed at half way (50%), to help and mark his opponent with the ball when he receives it.

- *(6). Assess harass*



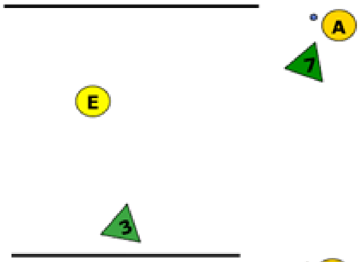
As in point 3, harass without committing any technique fault to direct opponent with the ball, but this time, must be reduced / closed the pass line of player with ball through to be placed in the interception line, between the player with the ball and his opponent without the ball.

- *(7) Ball in zone of pivot*



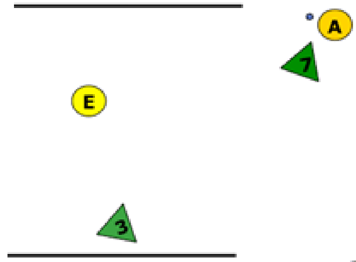
The relationship between first line players (center, left back and right back) with pivot, forces to study several situations, and, based on them, give appropriate instructions.

1. *With pivot placed on 6-m line*

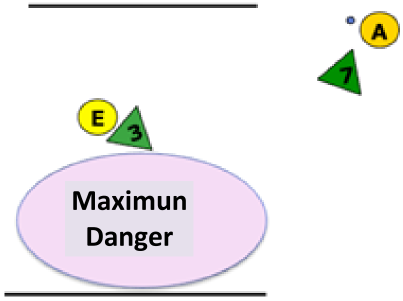


The defender of the pivot must perform a close marking of the pivot. The aim is that the pivot must not be able to receive the ball, because if he receives it, his chance to throw to the goal is very high.

2. *Pivot away 6-m line (8/10 meters)*



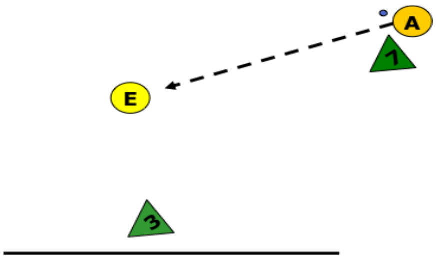
When pivot goes out the area near the goal area (6-m line), and acquires profundity, 8 or 9 m., **defender mustn't follow him, mustn't stick to him, nor perform a close marking.**



The principal reason is that if he follows the pivot by 8/10 meters, the central space, near 6 meters is very vulnerable, giving options to perform circulations of wings or circulations of first line players.
Also we would be without central defender, important defender because he usually is the last defender to give help to their teammate.

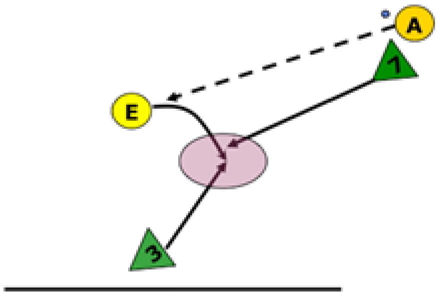
In this situation there is the possibility of not receiving the ball, and the possibility that he receives it. If the pivot receives the ball between 8/10 meters, the defender must observe and assess what performs pivot in that situation.

✓ *Option 1. The pivot does not turn around*

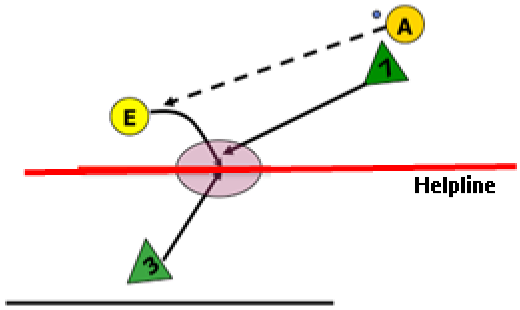


If the pivot does not turn and continues playing back to goal, his opponent will continue using a visual marking. Defenders of the player with the ball and pivot, should individually interpret the possibility that be perform a pass and go.

✓ *Option 2. The pivot turns around*



His direct opponent will perform a close marking to the pivot with ball, and even should make a technique fault, based on the dangerous of the pivot action.
But what is most important for us is that the defender of second line closer to the pivot turn, must make a help to his fellow defender of the pivot, to avoid thereby any action there of.



We argue that in this system, when a defending player stays above of the “helpline” or line of "offside", (marked this line by the situation of the ball between the two defensive lines), and especially when the player with the ball is oriented to the goal, must make a help. On one hand, it is quite difficult for the player with the ball do a backward pass, and on the other hand, in the case of the occurrence of this pass, its dangerousness is small.

- <u>*Groupal responsibilities*</u>

To carry out these groupal responsibilities the players must interact with their teammates applying collective defensive tactical means.
Basically we will use tactical means named "reactives", although the means "actives" are highly recommended.

- *(8) Crosses and circulations of wings*

When the opposing team applies basic offensive tactical means, as crossing, their defenders, shall make a change of opponent. Logically should observe the principles of change of opponent, especially to be in the same line. When a circulation of wing occurs, his opponent must avoid it, go with him, and then, if it is necessary, make a change of opponent with the defender of the pivot.

- *(9) Circulations of first line players (center, left back, right back)*

If a player of the first offensive line performs a circulation towards the pivot area, 6 meters, his direct opponent must avoid it and go with him, transforming the 3:3 defensive system to a 4:2. Later, if there are a crossing with the pivot, must perform a change of opponent.
Again, we note the importance of the central defender, not go out to look for the pivot, because if the circulation occurs, the possibility of change of opponent does not exist.
This solution is implemented in a generic way, as it could have its adaptations based on opposing players, mainly in anthropometric differences and development of physical and motor skills.

- *Collective Responsibilities*

We understand the collective term when all of the team players are involved in an action, while in groupal responsibilities those interventions are in small groups, usually 2 or 3 players, no more.

- *(10) Errors and Help*

Possibly this principle and collective tactical means defensive gets a greater role in this defence. We all understand that a profound defence generates more and larger spaces to be occupied by the attackers. So that, it is very important to fill these spaces if they are occupied by the opponents and, especially, if they are occupied due to defenders' errors. The only solution to solve a defensive error is that some teammate performs a help.

Important note about the help:

For give help, it is very important the use of collective tactical means called "preventive", such as coverage and lateral displacements ("basculation"). Thus, the basculation leads players to do coverage, and this is the essential first step for give help. Therefore, all players must understand that this is a group action, coordinated, not isolated. Only basculating, staying in coverage, and being aware of this, players will perform a correct help.

Final Considerations

Here we would like to highlight some important considerations:

- *"Where is the ball, is the danger."* All defenders must know, interpret and apply this principle. Sure that the game without the ball is very important! But, is even more important with the ball, because without a ball you can't get a goal. As elementary as true.
- *"It doesn't matter to leave specific position in defence and occupy other."* In this defensive system, where one of its fundamental principles is the help, it appears this idea, perhaps not widespread. But, if we do that in attack! Why not do so in defence? In addition, this abandonment of the specific position in defence is momentary, only last long enough for helping, successive or not, until the imminent danger disappears.
- *"Not one defender must stay above the helpline or "offside" line"* marked by the situation of the ball between the two defensive lines. The preventive tactical mean called coverage, must be permanently associated with this individual tactical defensive principle of helpline.
- *"The error must be trained".* It is necessary to explain and train solutions to take when a defender, a teammate, commits an error. It is idealistic to think that during a match we will not have any error in defence. So, what to do if we have a mistake? If perception, decision or execution of a defending player is bad or wrong, should we resign ourselves to concede a goal? In our proposal, the answer is No! The solution: the correct interpretation and application of the helps, successive or not.

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NUMERICAL SUPERIORITY DEFENSIVE ZONE: AN APPROACH TO AN ACTIVE DIMENSION (4:1:1)

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Summary
In this paper we present the use of a new zonal defensive system, the 4:1:1, an useful proposal of playing being in numerical superiority in defensive situations. We describe their functioning bases and their objectives. These include, from individual point of view, the application of the interception line as an individual tactical principle, and collectively, the use of tactical active means, mainly 2 against 1 (2x1). It specifies the defensive solutions to possible collective responses of the attacking team, with special attention to situations where it plays with pivot. The Olympic Women National Team of Brazil successfully tested this proposal in official competitions.

Keywords
Team handball, zonal defensive systems, numerical superiority in defence, active tactical means

"The one who doesn't invent, not live" (Ana María Matute)
"Every new idea inevitably involves three phases: first, it is ridiculous, later, it is dangerous, and finally, everyone knew it!" (Henry George)

Introduction
On 1st and 2nd July 2007, against Czech Republic, and later, on 7th and 8th July, at Betim (Minas Gerais, Brazil), against Ukraine, both preparation games for Pan American Games to be held in Rio 2007, the Olympic Women National Team of Brazil, put into practice this defence with excellent results. Since then, has always been used, both in official competition (Pan American Games, World Championships and Olympic Games) as in preparation matches, with very positive results. Therefore we want to thank Rita de Cássia Orsi for her inspiration and all handball players of Brazilian Olympic Team for their input and confidence in this 4:1:1 zonal defence model in numerical superiority. Thanks to all.

Functioning bases
The proposal defence 4:1:1, is a zonal defence, where there are two outside players, two center players and two advanced players. **Figure 1** reflects the name of the specific positions and their spatial distribution.

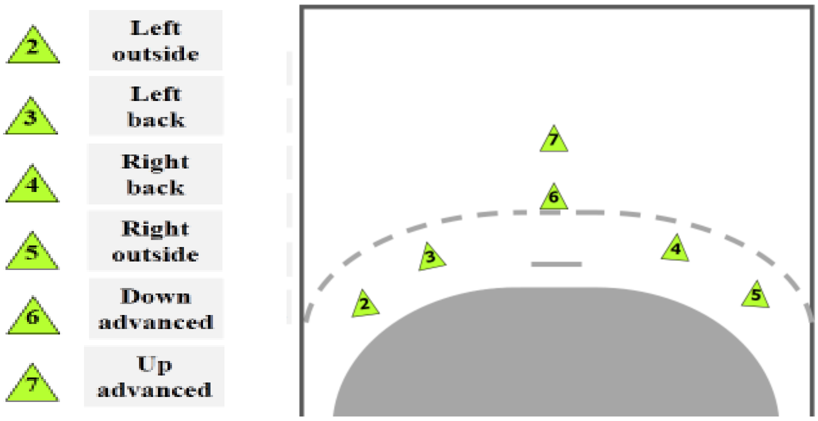

Figure 1: Identification of the specific positions of zonal defence system 4:1:1 and their location in the space.

Apart from the names of the different specific positions and their spatial distribution is necessary to determine the functions to be performed by each player, and even their characteristics. Authors like Jiménez Salas (1995, 2005) and Oliver (2004) studied differences between individually defence and zonal defence. Along this work we will use terminological classification proposed by Antón (2002) about the collective defensive tactical means.

The **outside players** do not differ in characteristics and functions with those of the 5:1 zonal defence system. They should dominate, especially, the individually marking, and the collective tactical medium called “attack to odd”.

With reference to **left-back defender and right-back defender**, they must mastery, especially, displacements, orientation and control of the opponent, and referring to the active defensive tactical means, the called 2 against 1 (2x1) and the “flotation”.

The **upper advanced** is governed by the same rules as the advanced traditional of the 5:1 performing his actions with more or less profundity, but never is an individually defence over somebody. At the individual level must master, especially, variety of displacements and the control of the opponent, besides a continuous dissuasion. Regarding collective tactic, should dominate the defensive tactical means called "active", and also the "preventive" and "reactive" tactical means, called "coverage" and "help", respectively.

Finally, the **lower advanced** player must dominate, lateral displacements, and the concept of "harass" without making technique fault. Regarding to active defensive tactical media must perfectly dominate the 2x1, since he is the responsible to provoke it.

Objectives

Prevent and hinder the game with the opposite area of the ball. This will be the main objective of the upper advanced player. He must place in various ways to hinder the pass-line between both sides, as proposed in **Figure 2.**

Hinder the circulation of the ball. The upper advanced must vary the distance and defensive intensity, with respect to the central player with a dual purpose. For one hand, losing profundity in relation to the goal, and for the other hand, shorten his time of perception and making decision, as shown in **Figure 3.**

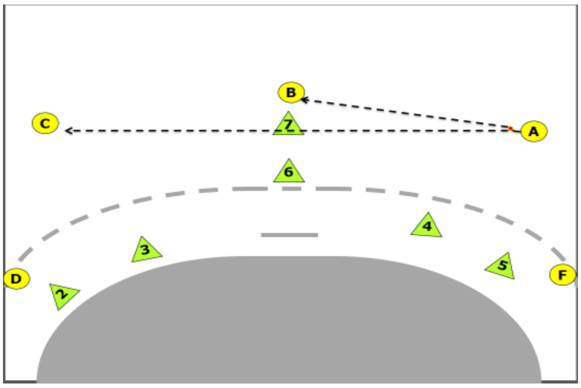

Figure 2. Position and situation of up advanced player for hinder or impede the passes between the attacking back-players.

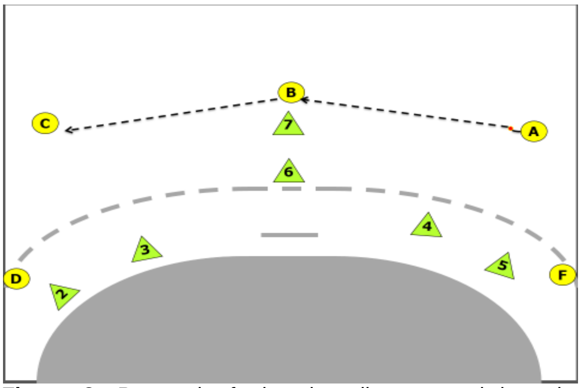

Figure 3. Proposal of changing distance and intensity between the upper advanced player and center-back, to hinder the movements of the ball.

The above individual objectives become collective objectives, when to those tactical intentions of impeding the game with the opposite area of the ball and avoid the circulation of the ball, joins the use of active defensive tactical means, applied by the other defenders.

Figure 4 shows the use of the "flotation", an active tactical medium, applied by left back defender. **Figure 5** shows the use of "attack to the odd" applied by the left outside, as an active tactical medium.

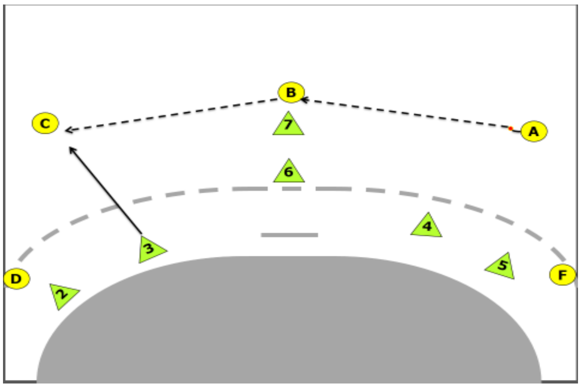

Figure 4. The use of "flotation" applied by left back defender, as an example of active defensive tactical means.

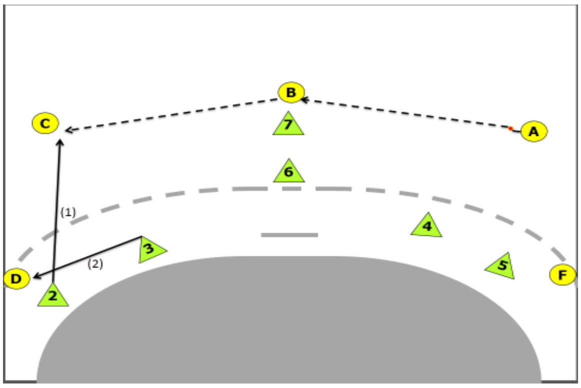

Figure 5. The use of "attack to odd" applied by the outside left defender, as an example of the active tactical means.

Getting numerical superiority 3 against 2, in zone of the ball

Thanks to the lateral movement of "basculation" made by lower advanced towards the area where is the ball, it will always be three players defenders (outside, back and down advanced) against 2 attacking players, (back and wing), as presented in **Figure 6**.

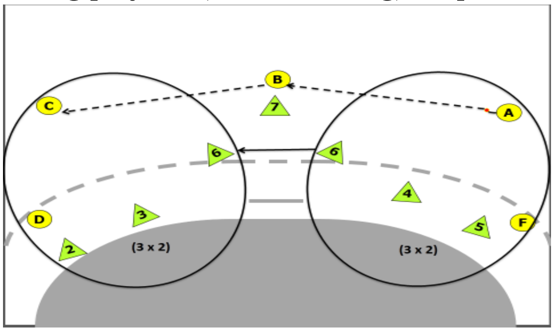

Figure 6. Search of numerical superiority in defence (3x2), thanks to the "basculation" made by down advanced.

Forcing the attackers (left and right back) to attack towards the sideline area

The main aim is to get 2 against 1 (2x1), formed by down-advanced and back, using a properly orientation, as we can observe in **Figure 7.**

Same as previous, adding more defensive activity through the use of "flotation" in the opposite zone

It is used the "flotation" in the opposite zone, applied by back defender, to avoid passing the ball to the opposite zone. **Figure 8** shows this situation.

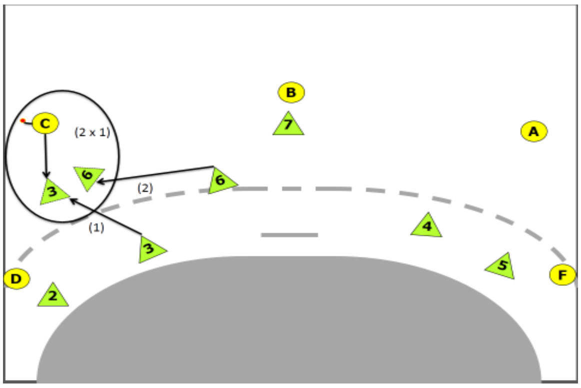

Figure 7. Getting defensive numerical superiority (2x1) by back defender and down advanced, against right back attacker**.**

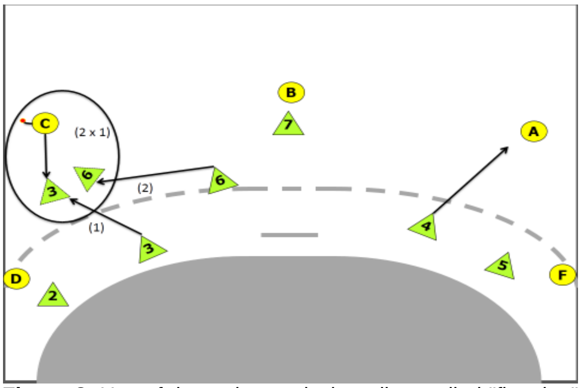

Figure 8. Use of the active tactical medium called "flotation" by the back of the opposite side of ball.

Same as above, but now applying the "attack to odd" by the outside defender to avoid passing the ball to the opposite zone. **Figure 9** shows this situation.

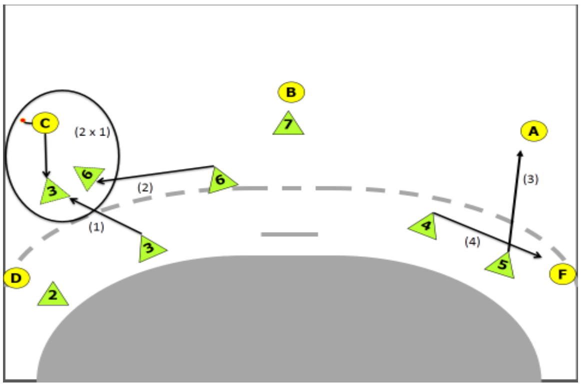

Figure 9. Use of the active tactical medium called “attack to the odd” by the right outside defender in the opposite side of the ball.

Situations when playing with pivot

If the opposing team decides to play his numerical inferiority with pivot, our 4:1:1 zonal defence will have to adjust to it, and applying the appropriate solutions.
The most important are:

Center- attacking player goes towards pivot position

If playing with a pivot by circulation of the center-back, our defence system 4:1:1 will become a 4:2 defence system, where one of the two advanced will occupy one of two advanced areas, and the left or the right-back defender will become the other advanced player, right or left, depending on what did his teammate.

- **First option.** The up advanced becomes down advanced, and down advanced accompanies center-attacking becoming defensive center. It is the most difficult to execute but is the most recommended because the up advanced continues performing advanced functions, and down advanced occupies the position of central defence. **Figure 10** represents this first option.
- **Second option.** The up advanced accompanies center. It is the most easy to implement in the absence of change of opponent but losing the primitive functions of each player, because the down advanced, usually in a lower position, is paired with center and the up advanced performs another function related to control of opponent and less coverage and help. In **Figure 11** we see the implementation of this proposal.

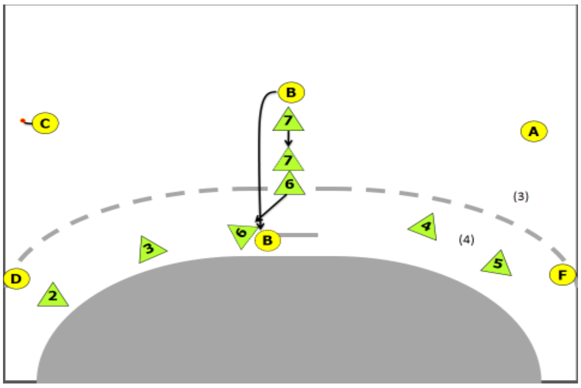

Figure 10. Defensive response to the circulation of center player to the pivot area: 1st Option.

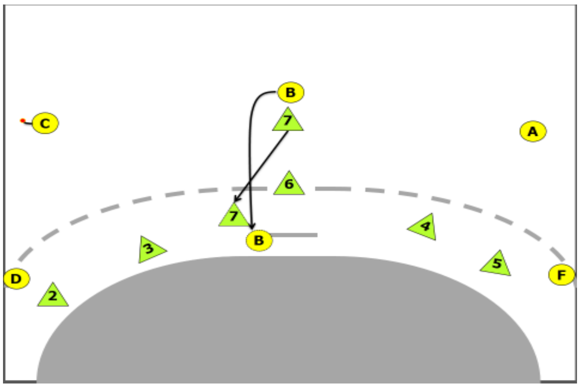

Figure 11. Defensive response to the circulation of center player to the pivot area: 2nd Option.

Back- attacking player goes towards pivot position

The simplest way to resolve this situation is that the direct opponent of back attacking player accompany him and become his defender in 6-m zone. This option is recommended for being the easiest to coordinate, as there is no change of opponent, but may still find difficulty in pairing the players, in proximity of 6-m, which are very different in anthropometrics, being the attacking player higher or stronger than the defender. This situation can be compensated later by a change of opponent between down advanced and back defender. **Figure 12** reflects this situation.

Wing-attacking player goes towards pivot position

In this situation his direct opponent, the outside, should go with him, keeping the rest of the structure, as shown in **Figure 13**.

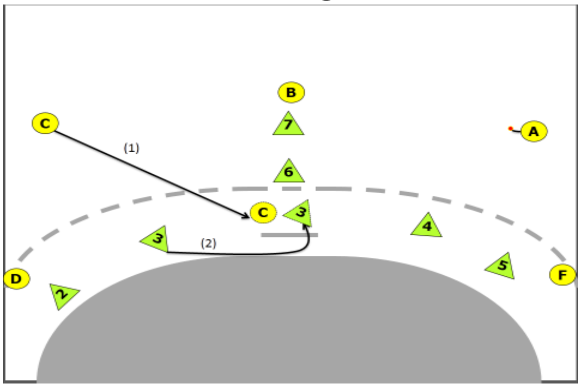

Figure 12. Defensive response to the circulation of right-back attacking player towards pivot position.

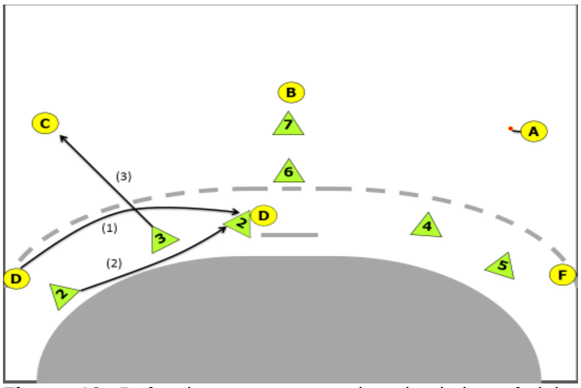

Figure 13. Defensive response to the circulation of right-wing attacking player towards pivot position.

Pivot game situations

If the opposing team played with a defensive system 2:3, with pivot, or 3:2 with pivot (by circulation of wing), in principle, the team will play in 3:1:2, where there will be three advanced (one low advanced, and two upper advanced, left and right).

The main idea is still the same, get 2 against 1 in side areas, but we can increase the use of active defensive tactical means (flotation and "attack to odd") in the opposite side of the ball. It is important the use of dissuasion as an individual tactic intention, as well as closing pass line. Undoubtedly, the presence or absence of pivot in ball area will condition the defence system.

- **Pivot in the zone of the ball**
  The distribution of responsibilities will be as explained in **Figure 14.**
- **Pivot in opposite zone of the ball**
  As there is no danger of pass to the pivot, we will try to intensify the 2 against 1 in zone of the ball, to avoid the ball reaches the opposite zone. **Figure 15** reflects this situation.

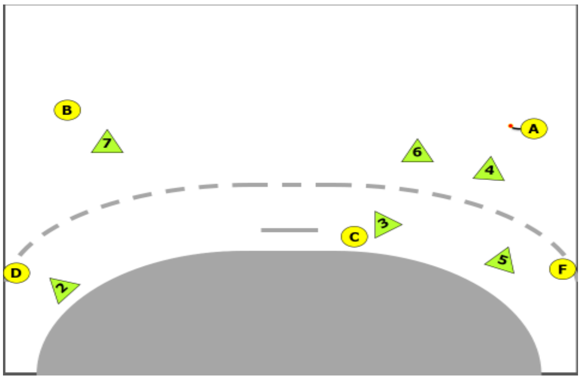

Figure 14. Distribution of responsibilities with pivot in the same zone of the ball.

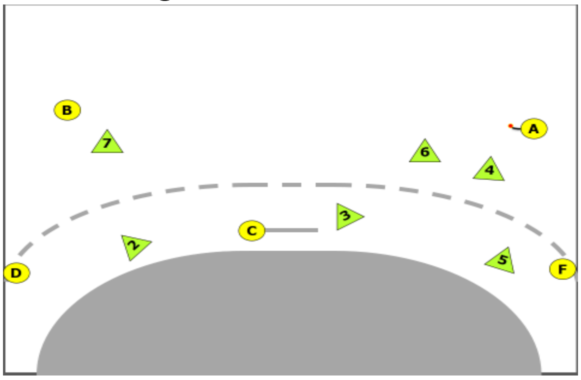

Figure 15. Distribution of responsibilities with pivot in the opposite zone of the ball.

2	Visual marking to the right wing. Coverage in central zone.
3	Marking closely the pivot. He can't receive the ball
4	Control left back, and searching 2x1.
5	Marking wing and be in coverage in central zone.
6	Search options of 2x1 in left side
7	Marking opponent, dissuasion, flotation, intercepting lines.

2	Visual marking to the right wing Coverage in central zone.
3	Visual marking to the pivot. Coverage in central zone.
4	Control left back and searching 2x1.
5	Marking wing and the central and coverage in central zone.
6	Search options 2x1 in left side
7	Marking opponent, dissuasion, flotation, intercepting lines.

Final considerations

From functioning bases exposed, other tactical situations that could occur will be always resolved following the methodology presented, which can be summarized as:

- Hinder the movement of the ball between the first line to avoid ball movements from one zone to the opposite zone, fluently.
- Get defensive numerical superiority (3x2) in the zone of the ball.
- Forcing back players to attack towards the less dangerous zones.
- Get defensive numerical superiority using 2x1 in sideline areas.
- Strengthen situations 2x1 with the use of active defensive tactical means of "flotation" and "attack to odd".
- Resolve situations with fixed pivot or as result of the circulation of the first line or the wings.

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A MULTI-FACETED ASSESSMENT OF ACHIEVEMENT MOTIVATION AND PERSONAL ORIENTATION IN RELATION TO THE GAME PERFORMANCE OF HANDBALL FEMALE PLAYERS.

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Summary
Motivational factors and personal orientation ought to be considered as a development game performance**.** Research data can be used to develop more effective programs of psychological preparation for athletes.

Keywords
Handball, elite sport, motivation, personal orientation, game performance.

Introduction
Study of the activities of players in the competition indicates the influence of motivational sphere on sports result. This is due to a small amount of active operations in the attack.

Ages 16-18 is the determining factor in the continuation of further professional athlete's career. It was during this age period is becoming a person. Teens strive to self-realization. Sport is one of this area to realize themselves. Young female handball players (16-18 years old) are taking part in the competition at the international level. At the same time, there is no clear understanding how much influence an achievement motivation and personal orientation on the athlete's game performance.

The purpose of this study was to analysis the relations between achievement motivation, different types of personal orientation and the game's performance of handball female players.

Material and Methods
The sample consisted of elite female athletes from handball (12 juniors and 13 adolescents). The research methods selected for the study were the test of achievement motivation by M. Sh. Magomed-Jeminov [2]. The test includes 30 statements that define the relationship to some real-life situations. Necessary to assess the degree of agreement or disagreement with each of the statements. It allows evaluating the general achievement motivation (motivation of success or motivation to avoid failure).

Achievement motivation can be defined as an individual's need to meet realistic goals, receive feedback and experience a sense of accomplishment. Is seen as a personality factor and describes our persistence in striving for success.

People are motivated to succeed are characterized by mobilizing all its resources and focus attention on the achievement of objectives. They are characterized by mobilizing all its resources and focus attention on the achievement of objectives.

Motive to avoid failure is a relatively stable disposition which causes a person to tend to avoid competition because of a fear of failure. It is related to a person's anxiety. A highly anxious person is more likely to avoid competition than one who is low in this construct. People are motivated to avoid failure are initially focused on the failure manifests self-doubt, anxiety and fear, does not believe in the possibility of success, fear of criticism, does not experience pleasure from activities which may be temporary setbacks.

To identify personal orientation was chosen orientation test form by B. Bass [1]. The questionnaire consists of 27 judgments, for each of which there are three possible answers corresponding to the three types of orientation of the person. The respondent must choose one answer that best expresses his opinion or corresponds to reality, and one which, on the contrary, far from most of his opinions or less corresponds to reality. Using this questionnaire we were identify personal orientation of handball player (goal orientation, orientation toward the self, social orientation).

An orientation toward the self is a psychological orientation in which an individual wishes to have direct personal rewards regardless of the effects on others working with that individual. A self-orientated person is often dominating, introspective, and socially insensitive.

Social orientational person focus more on collective concerns and Interpersonal relationship is given the utmost importance. Individuals who score high in Social orientation desire to maintain and, in many cases, increase the differences between social statuses of different groups, as well as individual group members. Typically, they are dominant, driven, tough, and relatively uncaring seekers of power. They are also prefer hierarchical group orientations.

Goal orientation is the degree to which a person focuses on tasks and the end results of those tasks. Strong goal orientation advocates a focus on the ends that the tasks are made for instead of the tasks themselves and how those ends will affect either the person or the entire company. Those with strong goal orientation will be able to accurately judge the effects of reaching the goal as well as the ability to fulfill that particular goal with current resources and skills.

There were also compared the dates of orientation test form and test of achievement motivation with parameters of game's performance (by seven international games in each age period) by descriptive statistics (percentage, mean and standard deviation) and inferential statistics (Pearson correlation coefficient).

Results

Firstly, the handball players were compared in terms of their personal orientation and achievement motivation. The participating showed a considerably lower level of achievement motivation.

		Motivation of success	**Motivation to avoid failure**
Mean value, points	18 year	-	144±16.12
	16 year	173±9.90	141±8.46

Table 1: *Achievement motivation of handball female players*

In juniors (average age - 18), the level of motivation to avoid failure ranged from 106 to 159 points, the mean value of 144±16.12. When in adolescents (average age - 16), the level of motivation to avoid failure ranged from 129 to 151 points, the mean value of 141±8.46. Furthermore, the several adolescents were detected the level of motivation of success ranged from 166 to 180 points, the mean value of 173±9.90.

		Orientation toward the self	Social orientation	Goal orientation
Center back	18 year	20.5±4.95	**35.5±2.12**	26±7.07
	16 year	20.5±10.61	25±9.9	**35±1.41**
Back	18 year	27±7.07	24.5±3.54	**29.5±10.61**
	16 year	23±3.61	28.8±4.82	**29.2±5.59**
Wing	18 year	27.7±0.58	**31.3±4.93**	22±5.29
	16 year	26±3.83	23.5±2.38	**31.5±1.73**
Pivot	18 year	20±1.41	**31.5±3.54**	28±0
	16 year	24.01±3.56	27.56±2.05	**29.1±2.15**
Goalkeeper	18 year	25.7±4.04	23±3.61	**31.3±1.53**
	16 year	22.7±5.13	28.7±4.62	**29.7±1.53**

Table 2: *Average dates Personal orientation of young athletes playing in different positions*

		Orientation toward the self	Social orientation	Goal orientation
Mean value, points	18 year	24±4.89	**31±4.82**	26±6.11
	16 year	24±5.03	26±5.23	**31±4.30**

Table 3: *Average dates of Personal orientation of young athletes*

Judge by the results obtained from orientation test form, in juniors dominates social orientation, the mean value of 31±4.82 points. While in adolescents dominates goal orientation, the mean value of 31±4.30. Which is manifested in the average number of shots per game.

		Goal	Shots	%
Center back	18 year	5.4	8.3	66 %
	16 year	10	13.7	73 %
Back	18 year	5.6	10	56 %
	16 year	11.4	19.9	58 %
Wing	18 year	5.7	8.4	68 %
	16 year	5.4	8.9	61 %
Pivot	18 year	4	5.3	76 %
	16 year	4.5	5.9	76 %

Table 4: *Average shots and goal of young athletes playing in different positions for game*

		Goal	Shots
Mean value, shots	18 year	20.7	32
	16 year	26.9	42.4

Table 5: *Average shots and goal for game*

Also were calculated Pearson correlation coefficient between dates of orientation test form and test of achievement motivation with parameters of game's performance.

		Effectiveness shots	Attack Interruptions
Orientation toward the self	18 year	-0.21	**-0.55**
	16 year	-0.36	0.2
Social orientation	18 year	**0.42**	0.25
	16 year	0.18	-0.28
Goal orientation	18 year	-0.13	**0.87**
	16 year	0.19	0.05
Motivation to avoid failure	18 year	-0.21	**0.48**
	16 year	-0.23	**0.49**

Table 6: *The values of correlation coefficients between achievement motivation, different types of personal orientation and the game's performance*

In juniors the statistical analysis revealed noticeable link and reverse between orientation toward the self and Attack Interruptions (r = -0.55). Between social orientation and Effectiveness shots was found a moderate relationship and direct (r = 0.42). A similar, statistically significant correlation (r = 0.48) was noted between motivation to avoid failure and Attack Interruptions. In addition, the high correlation and direct (r = 0.87) detected between goal orientation and Attack Interruptions.

Whereas the correlation is observed in adolescents only between motivation to avoid failure and Attack Interruptions (r = 0.49), the moderate relationship and direct.

Conclusions

These studies confirm the redistribution of priorities with age. The interpersonal relationships is dominate in juniors, while adolescents dominate goal orientation. The research data shows the value of motivation of success and goal orientation for the sport results. Therefore necessary to devote more time on mental preparation in the training process to achieve high results.

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ANALYSIS OF 2 VS 2 IN ORGANIZED ATTACK IN HANDBALL IN A SITUATION OF NUMERICAL EQUALITY OF 6 VS 6, DURING THE 2011 WOMEN´S WORLD CHAMPIONSHIP.

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Summary
The complexity of the relationships that develop between teammates and opponents is considered by many authors as an important and fundamental aspect in the final outcome of Handball matches (Prudente, 2006; Silva, 2008). This study aims to analyze, characterize and detect patterns of behavior in 2vs2, relating them to the defensive organization and the tactical means, in a numerical equality in organized attack on 2011 World Women´s Championships.

Keywords
Handball, 2vs2, Observational Methodology, Sequential Analysis.

Introduction

Handball is characterized by being a team sport game in a space shared by two teams with situations of intense character and fundamentally determined by collaboration with teammates and opponents contend, where the existence of physical contact is very present due to complex movements with and without ball, runs under varying conditions in the reduced space (Cruz, 2007). These factors occur in a large number of team Sports Games revealing the importance of tactical-technical factor emphasizing decisional capacity more than the execution capacity.

This dichotomy of cooperation between teammates and the opposition denotes a series of interactions and decisions that permanently affect the character of the game, turning either players or team's performance evaluation difficult. Despite this difficulty and the limited literature on this topic, the interest of some authors has grown in recent years as research has increased as well the assumption that success in team sports games is very dependent on relations between teammates and opponents (Garganta, 1997; Ribeiro, 2002; Prudente, 2006; Silva, 2008).

Therefore, we intend to analyze, characterize and detect patterns of behavior in 2vs2 in a numerical equality in organized attack, relating these patterns to use tactical means and the result of those means in games of 2011 World Women´s Championships.

By the importance given by the authors mentioned above is necessary that the offensive aspects of the process related to these duels must be study and a great way to do it is to use sequential analysis to detect patterns of behavior in Handball. Consequently, we analyzed the entire 2vs2 situations occurred in game in 16 games related to the organized attack in numerical equality 6vs6 in the preliminary round (8) and final round (8) of 2011 world women´s championship, in order to detect and characterize the different patterns of behavior.

With this study we aim to contribute to a better knowledge of the offensive process in Handball at the highest level as well as extend the literature on this topic.

Methods

Sample

The sample was composed of all 2vs2 situations occurred, totaling 383 sequences in game situation on organized attack in numerical equality 6 vs 6 in 16 games of World Championship, eight to the preliminary stage and eight from final stage.

Instruments

For the observation and analysis of the games, we developed a system that allowed observation record and analyze the offensive behavior during games.

The selection of variables for the analysis of the actions of players during the offensive sequences was based on studies conducted in the area of handball analysis of the game (Ribeiro, 2002; Prudente, 2006; Silva 2008; Volossovitch, 2008).

For the study was developed and validated an observation tool for the collection of data relating to the games. Built up a mixed format field with systems of categories, having defined the following criteria axial system: Defensive Organization, Defense Type, Play Time, Score, Specific Playing Positions, Tactical Mean and Action Result. Based on these criteria, were constructed systems of categories and indicators defined for each one.

Proceedings

All games were recorded from the television broadcast. It was from the images stored on the external drive which proceeded to observation.

From each criteria of the observational system, were constructed systems of categories and indicators defined for each one. Each sequence was observed first at normal speed, then both “slow motion " at normal speed as many times as necessary to properly record all situations occurring during the entire sequence offensive.

Data were recorded according to the order in which the events occurred corresponding to each code during offensive sequence, directly on the worksheet Excel program.
Cohen Kappa (K) was used to analyze the quality of data and to verify intra e inter observator.
For statistical analysis was used GSEQ 5.1

Discussion

In this chapter we present and discuss data from the study undertaken, whose objectives were to make a descriptive analysis of situations 2vs2, in attack and in a numerical equality, in order to ascertain if there are preferential relations between specific playing positions, the preferred tactical means used and the results of 2vs2 actions.

In this analysis we try to find values for elite teams participating in the Finals of the World Championships in 2011.

As we see in Figure 1, in this study we observed offensive sequences of all sixteen games, making a total of 383 of 2vs2 situations.

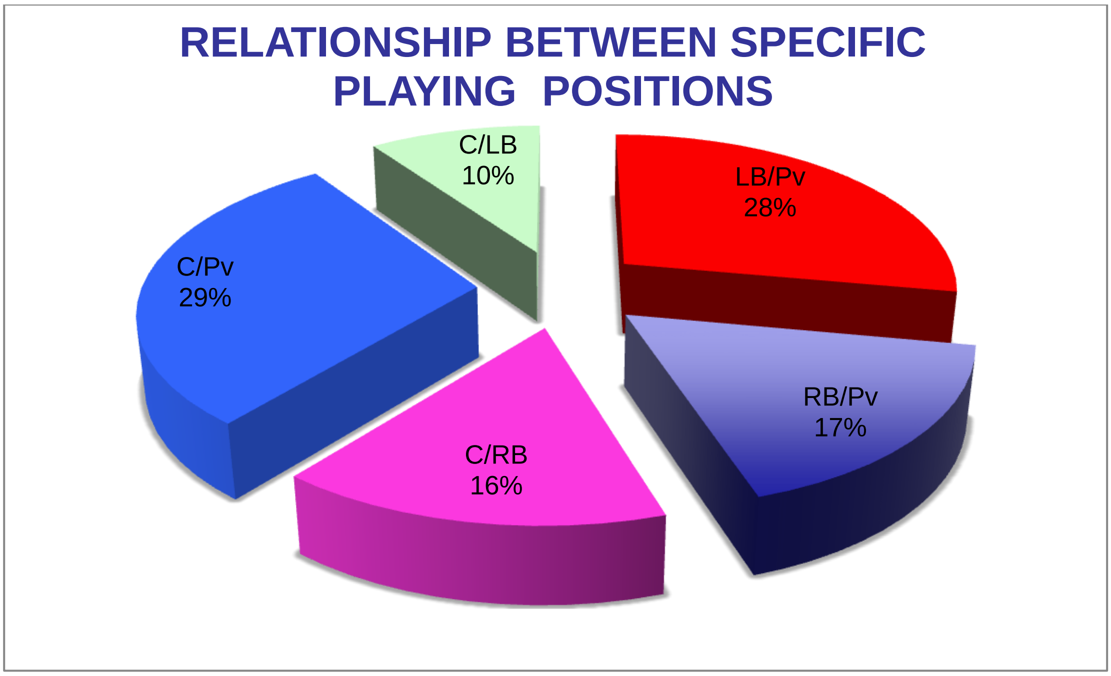


Figure 1 - *Relationship between specific playing positions*

In this figure we can observe that the relationship Central / Pivot and Leftback / Pivot were dominant with percentages of 29% and 28%. We can also emphasize the relationship between the Rightback / Pivot (17%) and Central / Rightback (16%).

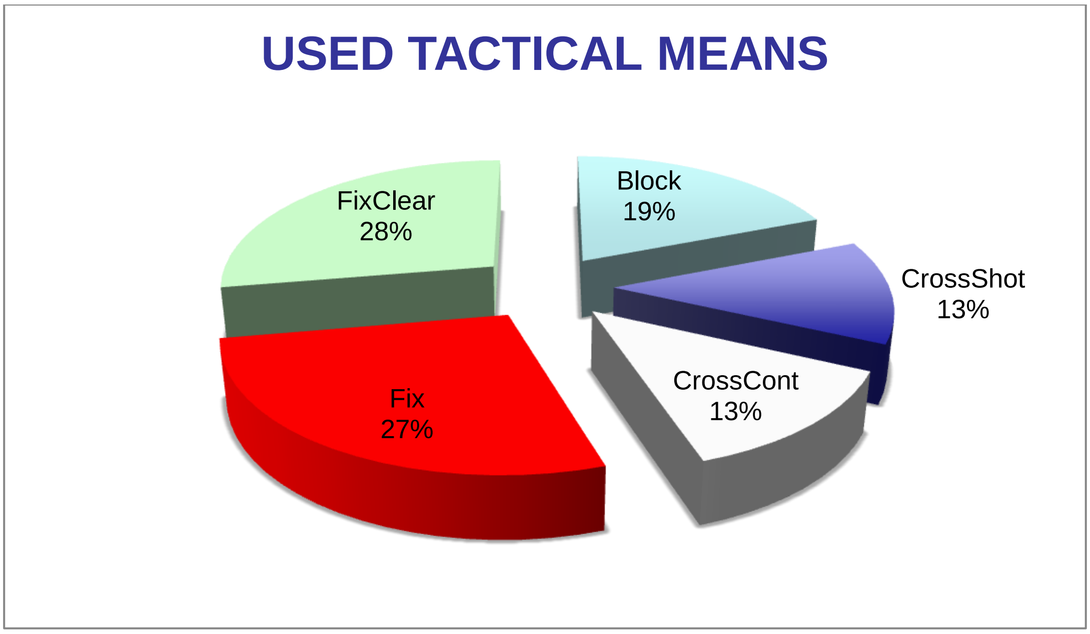
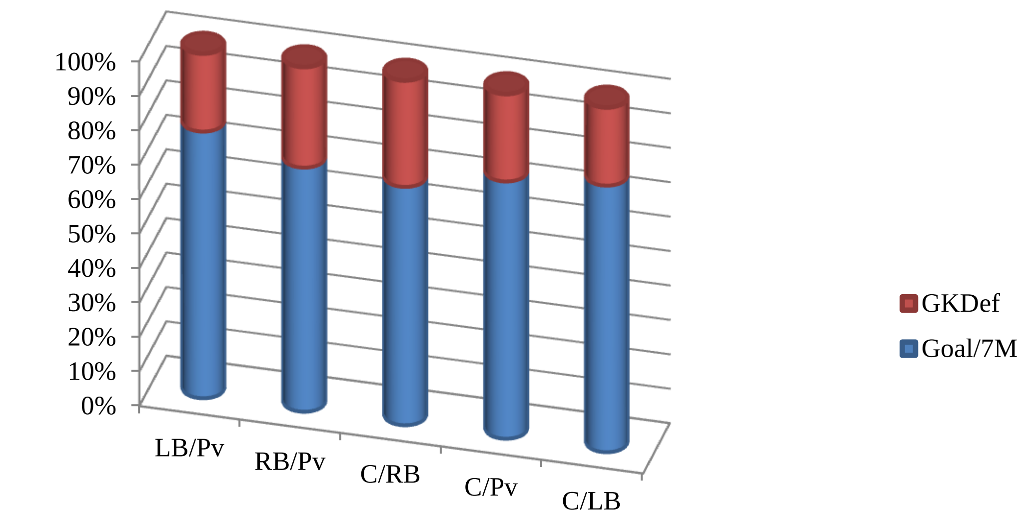


Figure 2 - *Used Tactical Means*

In order to the most used tactical means there was a clear preference for both FIX / CLEAR (28%) and FIX (27%). It´s rather interesting that both of them are associated with the use of two different lines (first and second row), with the main difference between them being the shooter player. The one mostly used had as shooter pivot player, the second one the shot was made by the Left or Rightback or Central.

In this figure we also assess that the cross situations occur in much less than the first (roughly half), we can consider as principle reasons the defensive systems used, the low efficiency of first-line shot or lack of left-handed Rightbacks, conditioning kind of game of various teams.



	LB/Pv	RB/Pv	C/RB	C/Pv	C/LB
GKDef	22,5	29,1	30,8	25,3	22,6
Goal/7M	77,5	70,9	69,2	74,7	77,4

Figure 3 - *2vs2 actions results*

If we consider that the 7 meters is a situation of imminent goal, we note that in Figure 3 situations occurring 2vs2 had a very high rate of success in the order of 70% (being the occurrence of success or goal attainment or achievement free 7 meters). This graph reinforces the idea revealed by some authors and coaches who appreciate or identify these situations 2vs2, as being crucial in achieving positive results.

Table 1 - *Analysis of the relationship between specific playing positions and tactical means using the sequential analysis*

B.C. Specific Playing Positions	BLOCK	CROSS/ SHOT	CROSS/ CONTINUITY	FIX	FIX/ CLEAR
Leftback/Pivot (LB/Piv)	**2,79**	**-4,67**	**-4,38**	**2,72**	**--------**
Rightback/Pivot (RB/Piv)	**--------**	**-3,02**	**-3,46**	**4,22**	**--------**
Central/Rightback (C/RB)	**-4,09**	**6,45**	**12,17**	**-5,18**	**-5,22**
Central/Pivot (C/Piv)	**2,98**	**-4,51**	**-4,91**	**-------**	**4,19**
Central/Leftback (C/LB)	**-3,11**	**9,98**	**3,68**	**-3,55**	**-3,96**
Behaviors that shows significant values (>1,96) in the prospective analysis of the offensive sequence from the behavior criteria (B.C.) "Specific Playing Positions"					

Table1 presents the relationship between specific playing positions that activate or inhibit the occurrence of tactical means.

In the table above we see that there are behaviors that showed significant values (> 1.96) in the prospective analysis of the offensive sequence from the criterion conduct ”Specific Playing Position".

We have proved the existence of behavior patterns, i.e., they occur more than randomly:

- The relation - Leftback / Pivot activates tactical means Fix and block;
- The relationship Rightback / Pivot enhances the occurrence of tactical mean Fix;
- Relations Central / Rightback and Central / Leftback activates both Cross with shot and cross with Continuity;
- The relationship Central / Pivot powers tactical means Block and Fix / Clear.

On the other hand, there are behaviors that are inhibited or that there is a high probability of not happen:

- Relations Leftback / Pivot , Rightback / Pivot and Central/Pivot inhibit the occurrence of some tactical means like Cross with shot and Cross with Continuity ;
- Relations Central / Rightback and Central / Leftback inhibit the occurrence of the block, Fix and FixClear .

Table 2 - *Analysis of the relationship between tactical means with the result of that use using sequential analysis*

B.C. Tactical Means	GOAL	7M	GOALKEEPER DEFENSE
Block	-2,00	4,80	-------
Cross/Shot	-------	-2,68	2,28
Cross/Continuity	-------	-------	-2,06
Fix	-------	-2,99	3,16
Fix/Clear	-------	-------	-2,49
Behaviors that shows significant values (>1,96) in the prospective analysis of the offensive sequence from the behavior criteria (B.C.) "Tactical Means"			

Concerning the use of tactical means and the action result, table 2 shows the occurrence of patterns of behaviors, specifically that the use of block actives strongly 7 meters occurrence. On the other hand we see that there is a high possibility of occurrence of goalkeeper defense whenever there are cross with shot or when teams use the tactical mean fix.

Conclusions

The final propose of this study was to analyze, characterize and detect patterns of behavior in 2vs2 in a numerical equality in organized attack, relating these patterns to used tactical means and the result of those means in 2011 Women's World championship.

As final conclusions we found that the tactical means most used were FIX and FIX/CLEAR, followed by the BLOCK. These results show that women´s teams give much importance to the relation between first (Leftback, Central, Rightback) and second line (Pivot). Analyzing the result of the 2vs2 actions, we hold true that these actions have a high success rate (the lower percentage was 69, 2%). We also detected some behaviour patterns:

- The relation Leftback / Pivot activates tactical means Fix and block;
- The relationship Rightback / Pivot enhances the occurrence of tactical mean Fix;
- Relations Central / Rightback and Central / Leftback activate both Cross with shot and cross with Continuity;
- The relationship Central / Pivot powers tactical means Block and Fix / Clear.

We propose a larger scale study or a study in order to ask and see if clubs and national teams work in order to increase the effectiveness of these 2vs2 actions.

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IDENTIFICATION OF OFFENSIVE ACTION PATTERNS IN TEAM HANDBALL

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Summary
The aim of this study was to investigate sequential offensive action patterns in team handball. Six games of the EHF-EURO Men-18 were analyzed for this study. Position data consisting of shots and up to five preceding passes were analyzed by artificial neural network (ANN) to identify data patterns. The analysis by ANN successfully identified 42 different offensive patterns and therefore revealed the potential of ANN in the analysis of offensive patterns in team handball.

Keywords
Sequential actions, team tactics, artificial neural networks, notational analysis

Introduction
Team handball coaches are interested in the strengths and weaknesses of opponents and their own team. It is e.g. important to know which offensive tactics the opponent team prefers to develop successful defensive strategies. In the last decades the use of computers for notational analysis made it possible to evaluate a large number of game events (Hughes & Franks, 2008). Performance indicators can give a general view about team tactics and individual behavior and may reveal valuable information for the planning of training (Meletakos & Bayios, 2010; Meletakos et al., 2011). However, since focus on single action analysis only provides restricted insight into tactical behavior, Carling et al. (2008) suggested analyzing action sequences, i.e. chains of sequential single actions. As far as known to the authors, research in the field of actions sequences is rare. Attempts analyzing dependencies between single actions in terms of actions sequences in beach-volleyball (Koch & Tilp, 2009) have shown the additional value of connecting actions to sequences. Lately, Link & Ahmann (2013) used position data to analyze action sequences also in beach-volleyball. Interesting approaches to analyze action sequences as temporal patterns (T-patterns) in sports like soccer, boxing, basketball, and swimming are summarized in a review by Jonson et al. (2010). In team handball, Lopes et al. (2010) used sequential analysis to detect temporal patterns in defense systems. Recently we presented a method to analyze action sequences in order to identify offensive behaviors in team handball (Schrapf & Tilp, 2013). In the present study we include goal and overall success information and relate it with sequences of position data of game actions in team handball to identify successful offensive behaviors.

Methods
For the present study six games from the EHF EURO-Men-18 Championship in Hard (Austria) were analyzed. Analyses of the six games included data of eight teams (Croatia, Denmark, Finland, Romania, Serbia, Slovenia, Spain and Switzerland). Each game was captured by eight cameras to cover the whole playing area and to be able to calculate ground position of players. Subsequently, all shots and up to five passes prior the shot where annotated with custom-made software. Figure 1 shows the user interface of the software's annotation dialog.

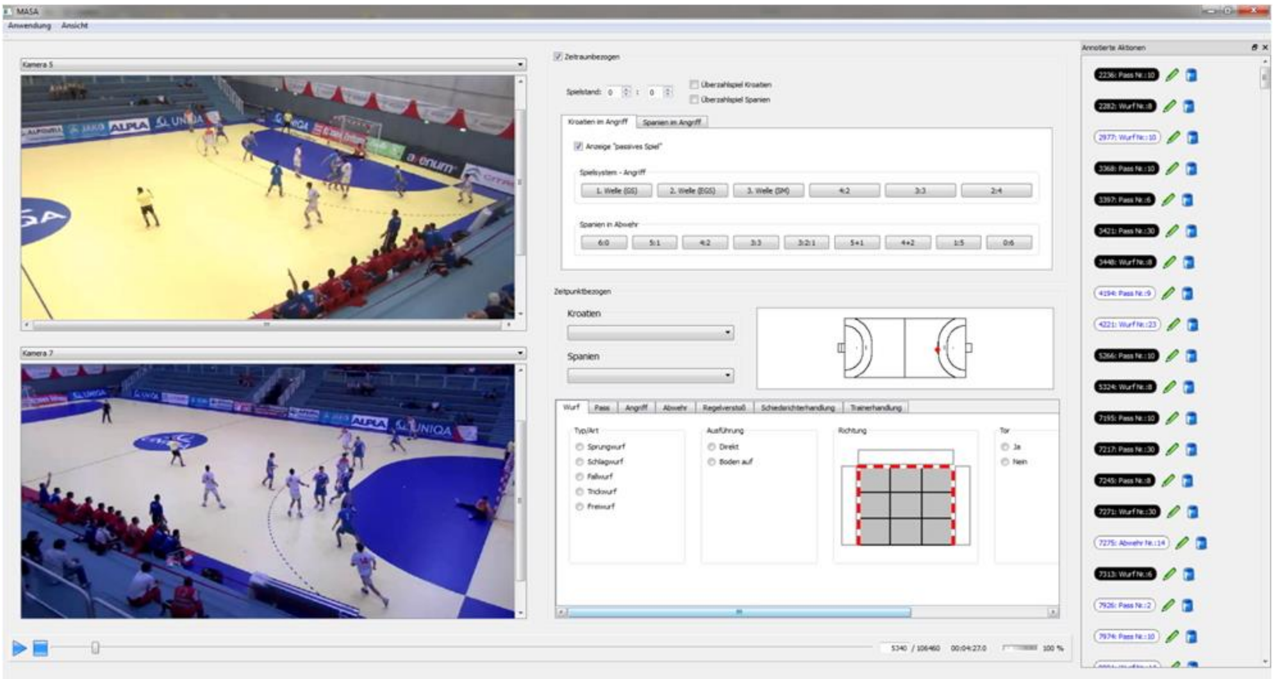

Fig. 1: *Graphic user interface for the annotation of data*

Each annotation includes the video time stamp of the action and the ground position of the ball carrier on the field. The annotation of each passing action also included the ground position of the receiving player. Furthermore, shot actions were annotated including shot position and information about goal success. In total 3212 single actions were recorded.
Subsequently, each shot action and the related passing actions were combined to an action sequence. The result of this procedure has led to 612 action sequences. Thus, each of these action sequences represents the path of the ball from the last five passes to the shot-position as shown in Figure 2.

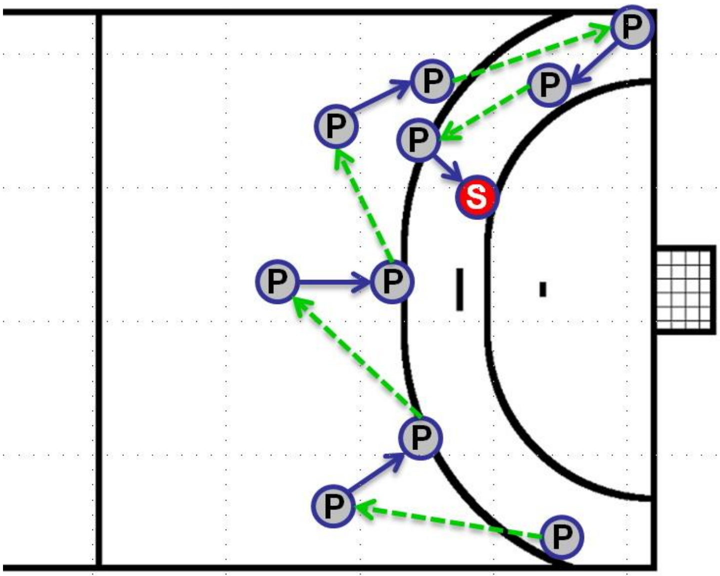

Figure 2: *A representation of an action sequence in team handball. P=position of passing or receiving player, S=shot position. Solid blue arrows represent running paths, green dashed arrows represent ball path*

Artificial neuronal network software (Perl, 2002) was used to analyze the action sequences. In order to obtain suitable entropy for the training-process of the net, original data had to be

enlarged to an amount of 3060 datasets by quintupling it with a noise of 15%. To minimize unwanted learning effects during the net training, datasets were also permutated.
Subsequently, the artificial neuronal network with a dimension of 400 neurons was trained to classify these action sequences. As a result, each neuron of the network represents an action sequence pattern. Furthermore, the artificial network pools similar neurons to clusters. These clusters represent similar offensive playing behavior. Similarity resolution, a parameter which defines the selectivity between similar and dissimilar neurons, was set to 70%.

For the analysis of action sequences, the artificial neuronal network was tested with the original dataset. Subsequently, patterns of action sequences were plotted to review the affiliation of the single action sequences to the corresponding cluster and the most often played patterns where outlined.

Results
The training process of the artificial neuronal network resulted in an amount of 32 clusters. Ten network neurons could not be assigned to a cluster. Thus, these single neurons represent different playing patterns. Summarizing, the net identified 42 different offensive strategies (32 clusters and ten single neurons) of the different teams. Figure 3 shows the result of the net-training whereas Figure 4 shows the frequency distribution of played action sequences related to the identified clusters. Furthermore, Figure 4 indicates the relative goal success of the identified patterns. It can be observed that goal success varied substantially between the different patterns.

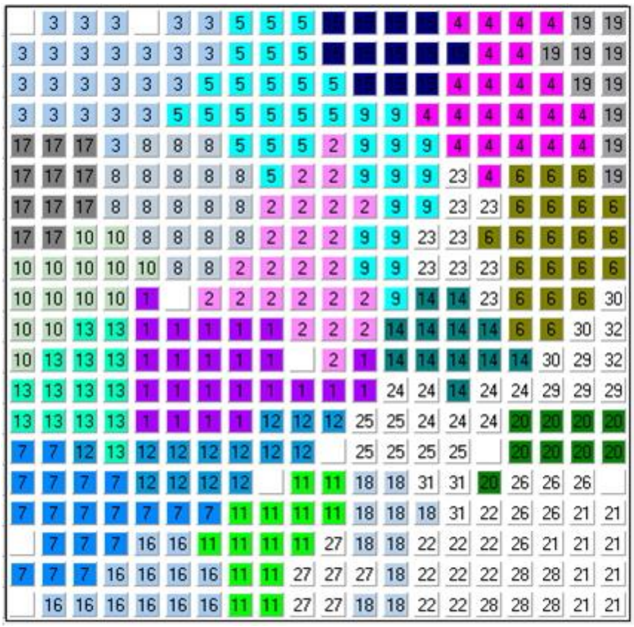

Figure 3: *The result of the analysis with artificial neural networks. Each colored region of the net with the same number represents a different offensive playing pattern.*

When testing the net with the original action sequence data, all of the original action sequences could be assigned to a neuron. A benchmark for the similarity between actual played action sequences and the patterns they were assigned to is the average deviation. In this study the average deviation was 2.9%. This means that the average distance between the position of a single action and the corresponding position at the representing neuron lies within 1.2 meters.

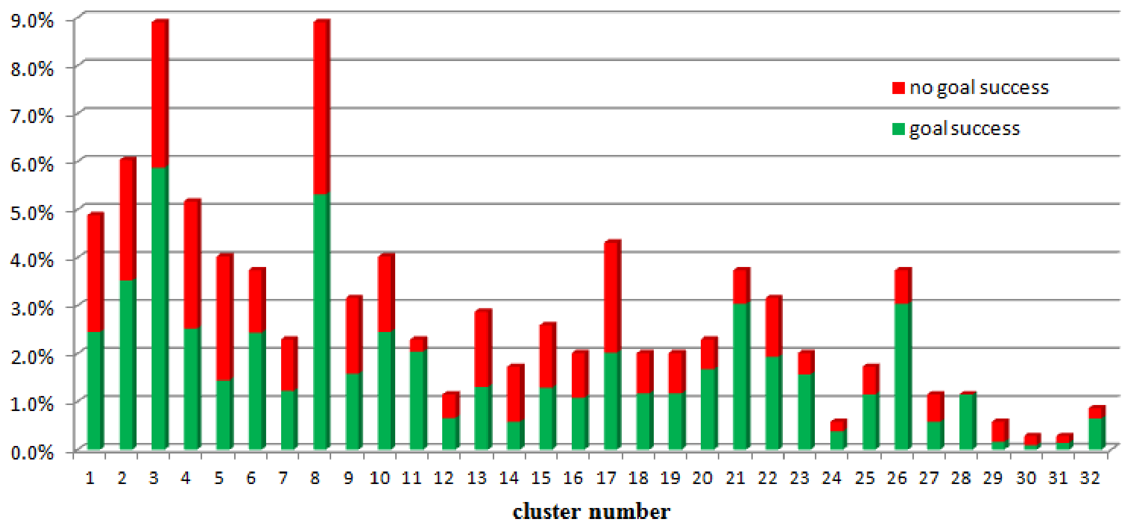

Figure 4: *Frequency distribution and relative goal success of observed offensive patterns. Green areas represent goal success; red areas represent no goal success.*

Discussion

Results demonstrate that artificial neuronal networks are able to classify action sequences played in team handball and therefore identify offensive patterns (Schrapf & Tilp, 2013). Expert reviews indicate that the classification and assignment of the original action sequences have a promising accordance with the detected patterns of the neuronal network. The amount of detected patterns appears to be manageable and accurate so that advises of practical relevance to coaches and athletes can be given.

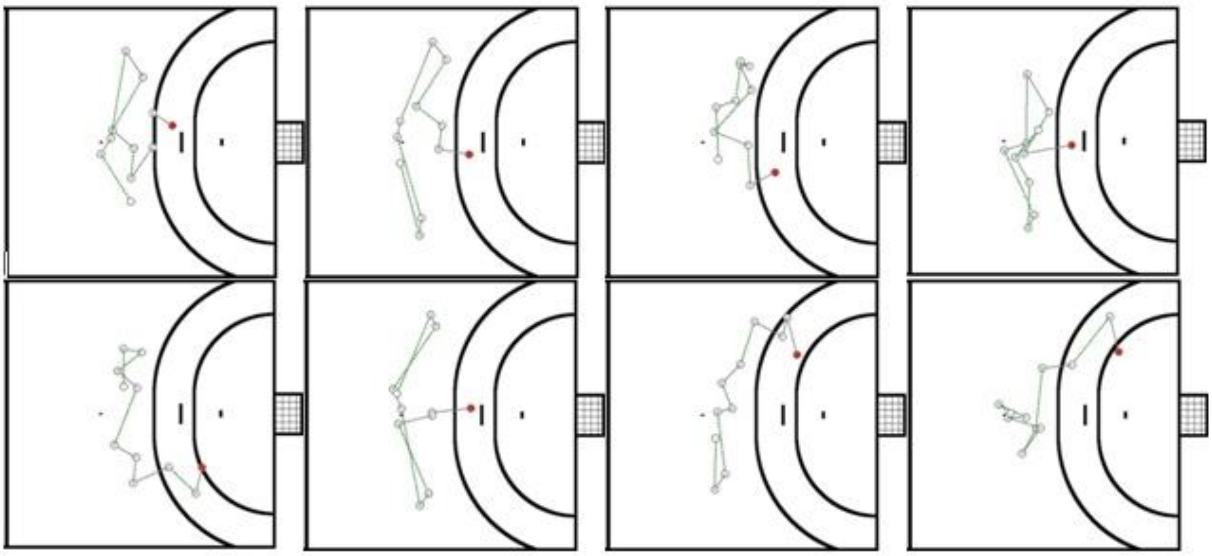

Fig. 5: *Eight different offensive patterns determined by ANN. Please note that some patterns differ substantially in the preceding passes but not in the shot position.*

The advantage of the analysis of action sequences instead of single actions is represented in Figure 5. Please note that the shot position of the different playing pattern is very similar in some cases. Classical approaches to analyze shot attempts would not be able to differentiate between these actions because important context information, i.e. how the team came to the shot position, is missing. Adding information about shot success and the involved players, one can assess the different offensive tactics which lead to a promising shot position. Therefore, an important advantage of action sequence analysis against classical analysis of single actions is the potential to get information how teams behave to obtain success.

Interestingly, a closer inspection of the most often played patterns revealed that 49% of all played action sequences are represented by only 8 clusters. This indicates that the different teams of the analyzed sample played with surprising little variations. To further examine the importance of variation in offensive tactics, we performed a correlation between the numbers of played patterns of each team with its end ranking in the tournament. The resulting low correlation coefficient r_s=0.6 (Spearman) however, indicates a rather low relationship between offensive variation and success.

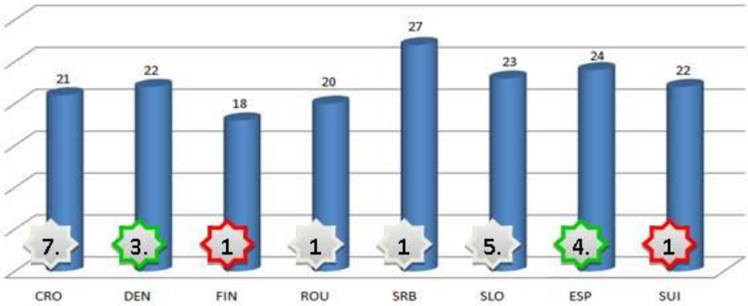

Figure 6: *Average number of played offensive patterns/game. Numbers below indicate tournament end ranking.*

Although the results are quite promising they have to be taken with care due to possible shortcomings of the used dataset and the preprocessing for the training of the artificial neuronal network. The used dataset contains action sequences with a length from 1 to 5 passes prior the shot. Further attempts with a fixed quantity of passes prior the shot have shown that action sequences with a small number of passes may distort action sequences with a larger number of passes. Thus, further studies are needed which use separate neuronal networks for each quantity of passes prior the shot. A second shortcoming may appear with extremely rarely occurring action sequences. These action sequences possibly affect the assigned neurons insufficiently during the training process and may result in incorrect patterns. To bypass this shortcoming, extremely rare action sequences could be identified and duplicated within the preprocessing of data for the network training. Furthermore, noise ratio for the duplication of the dataset for the net-training affects training-results. E.g. lower noise ratio may lead to better selectivity between the neurons and therefore a smaller deviation for the most often played patterns will be gained.

Conclusions

Summarizing, the study revealed the applicability of artificial neuronal networks to identify offensive patterns in team handball. The presented methods are able to detect playing patterns in an appropriate amount and with promising accordance to actually played actions sequences. In addition, it could be discovered, that dominating patterns in team handball exist. At least in the analyzed sample the variation was low and variation does not seem to be strongly connected to overall success.

An important future application will be the analysis of preferred offensive tactics of individual teams and possible temporal assignments of different playing-patterns, e.g. in the game end phase or during time-penalties. Another future goal is to integrate defensive behavior of the opponent team to analyze interaction between the opposing teams.

Acknowledgement

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TENDENCIES IN MODERN HANDBALL AFFECTING WOMEN'S TEAMS AFTER THE OLYMPIC GAMES IN LONDON AND THE EUROPEAN CHAMPIONSHIP 2012

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Summary
In this study, we have tried to make a retrospection of the contemporary state of handball by making an analysis of game parameters of the best female handball teams participating in the Olympic Games (OG) in London and in the European Championship (EC) during the year 2012.

International Handball Federation of (IHF) have established an orderly and very equitable ranking system for the teams in the final phase of the above specified events, taking into account the constantly expanding handball geography. Female handball was for the first time included in the OG (during) in 1976 [2], and the beginning of the European Handball Championship was made in 1994 [3]. The most first places are held by Denmark – 3 first places at OG and at EC respectively, Norway has 2 Olympic titles and 5 titles in the EC respectively, Russia and South Korea have 2 Olympic titles each of them, etc. (Table 1).

Table 1: *History of the Olympic Games (1976 - 2012) and European Championships (1994 - 2012 г.) for Women*

Olympic Games (1976 – 2012)				European Championships (1994 – 2012)			
	Year	**Host**	**Champion**		**Year**	**Host**	**Champion**
1	1976	Montreal	**USSR**	1	1994	Germany	**Denmark**
2	1980	Moscow	**USSR**	2	1996	Denmark	**Denmark**
3	1984	Los Angeles	**Yugoslavia**	3	1998	The Netherlands	**Norway**
4	1988	Seoul	**S. Korea**	4	2000	Romania	**Hungary**
5	1992	Barcelona	**S. Korea**	5	2002	Denmark	**Denmark**
6	1996	Atlanta	**Denmark**	6	2004	Hungary	**Norway**
7	2000	Sydney	**Denmark**	7	2006	Sweden	**Norway**
8	2004	Athens	**Denmark**	8	2008	Macedonia	**Norway**
9	2008	Beijing	**Norway**	9	2010	Denmark/Norway	**Norway**
10	2012	London	**Norway**	10	2012	Serbia	**Montenegro**

Note.: The information used in the compilation of the table is taken from EHF [3] and IHF [4]

Several sensations occurred at the two most prestigious women's forums in 2012: in the first place, this was the discrown of Norway - quintuple European Champion; in the second place, that was the omission of the Olympic Tournament's quarter finalist Denmark (three-times gold medalist at OG and EC); and thirdly, the fourth place of South Korea (two-times Olympic Champion) in London.

The contemporary professional sport puts quite high requirements on competitors. Unlike most of the individual sports, these requirements for the games and particularly regarding handball, are in a broader range and have their own specificity. „The speed of decision-making, its synchronization with a group of team players, the assessment and anticipation of the game situation (development), create a highly efficient and attractive games"[1].

Keywords
Contests, handball athleticism, numerical superiority, numerical minority

Methods

Aim: to establish the contemporary tendencies in the game of handball through comparative analysis of performance parameters of the participating teams at the OG and EC.

The subject was composed of the 12 teams that participated in the final handball tournament at the OG in London and the 16 finalist teams at the EC in Serbia in 2012.

The methods of research involved a theoretical analysis of the official computer statistics from the women's handball tournament at the Olympic Games and at the EC-2012. The statistics contained statements regarding the conduct of each respective match; the number of goals scored in the separate phases of offence and their percent efficiency; the results of the teams in numerical equality and numerical inequality during the EC; goalkeeper efficiency.

Results and discussion

Average height and age of female handball players

There is a tendency in modern handball of increasing the body height of female handball players – especially those playing in the back line of offence, and in the recent years - of the pivots. The values in table 2 show that the average body height of the eight teams that ranked at the two forums (OG and EC) is one and the same – 177 cm. The lack of any difference in this indicator points out that regardless of the imposed younger newcomers, the height requirements have been preserved. The "record-holders" in this respect are the teams of Denmark, Russia and Croatia with 11 new handball players each of them, followed by Norway – 7 and Montenegro with six new players. This is the point to note that, regardless of this factor, the team of Montenegro made an incredible height selection, which is by 3 cm above the one at the OG. All the remaining teams have lower values with respect to body height, or have preserved it at the same level (Norway and France). The second exception is the team of Spain with the increase of 1 cm (from 174 to 175cm).

In terms of age, even though for a period of about 4 months, all teams (see table 2), except France, have created their teams younger by 2-3 years. Here, the record is held by Russia – the average age of the team at the OG is 28 years, and at the EC – 23 years. Again, as in terms of the body height parameter, the new European Champion – Montenegro has an advantage over Norway (24 against 27 years of age). These two factors have significantly contributed for the deposition of the five times European Champion – Norway by the unknown until then OG team of Montenegro. Another analogy we need to make is that the factor of rejuvenation has also positive effects for the ranking. Thus, for example, Denmark from the 9th place at the OG took the 5th place at the EC, Russia from the 8th place moved to the 6th place, Sweden from the 11th place moved to the 8th place. In contrast to this, France, which participated with almost the same team and the same parameters (body height -178 cm and age – 26 years), slipped down from the 5th to the 9th place at the EC.

Table 2: *Comparative data on height, age and ranking of the eight female teams that participated at the OG and EC 2012.*

Olympic Games – 2012				European Championship – 2012			
Average height (cm)	Average age	Ranking	State	Ranking	Average age	Average height (cm)	Number of new players (competitors)
175	26	**2**	**MONTENEGRO**	**1**	24	178	6
176	28	**1**	**NORWAY**	**2**	27	176	7
178	27	**9**	**DENMARK**	**5**	24	175	11
180	28	**8**	**RUSSIA**	**6**	23	179	11
178	27	**11**	**SWEDEN**	**8**	24	176	7
178	26	**5**	**FRANCE**	**9**	26	178	5
174	30	**3**	**SPAIN**	**11**	28	175	5
180	28	**7**	**CROATIA**	**13**	26	178	11
177	**28**		**Total for the 8 teams participating at the OG and EC 2012**		**25**	**177**	-
177	**27**		**Total for all participants**		**26**	**176**	-

Note.: The information used in the compilation of the table is taken from EHF [3] and IHF [4]

Team efficiency and shooting efficiency from various positions and distances.

During all 38 matches of the Handball Tournament at the Olympic Games (table 3) 3498 shots into the goal have been made, while 1909 goals have been scored with an efficiency of 55%. At the European Championship (table 4), the shots during the 47 matches were 4518 as a whole, 2381 of which have resulted in scoring a goal with an efficiency of 53%, i.e. by 2% lower than the OG. On an average basis, 92 shots were made in a match at the OG, 52 of which have been realized with an efficiency of 55%, while at the EC, they were respectively 96 shots and 53 goals (53% efficiency).

Table 3: *Shots efficiency of women's teams at the OG – 2012*

Team	Number of matches	Total shots		6 m. shots		Wing shots		9 m. shots		7 m. throws		Fast break		Breakthrough	
		G/S	%	G/S	%	G/S	%	G/S	%	G/S	%	G/S	%	G/S	%
ANG	5	132/235	56	13/26	50	21/30	70	53/120	44	18/24	75	14/16	88	13/19	68
BRA	6	156/271	58	23/27	85	32/55	58	50/129	39	15/19	79	21/22	95	15/19	79
CRO	6	167/262	64	34/48	71	22/38	58	39/83	47	16/23	70	29/34	85	27/36	75
DEN	5	113/235	48	19/23	83	15/31	48	40/119	34	15/21	71	16/28	57	8/13	62
ESP	8	201/348	58	51/75	8	26/46	57	34/104	33	29/43	67	17/25	68	44/55	80
FRA	6	147/285	52	35/51	69	12/26	46	41/128	32	8/12	67	37/47	79	14/21	67
GBR	5	91/204	45	21/27	78	14/35	40	16/79	20	14/20	70	14/20	70	12/23	52
KOR	8	214/398	54	30/45	67	28/51	55	69/176	39	30/47	64	26/37	70	31/42	74
MNE	8	210/358	59	41/55	75	44/71	62	47/125	38	27/32	84	29/40	73	22/35	63
NOR	8	196/380	52	40/62	65	32/48	67	66/177	37	14/25	56	30/44	68	14/24	58
RUS	6	174/293	59	18/23	78	21/45	47	44/117	38	21/26	81	40/48	83	30/34	88
SWE	5	108/229	47	24/33	73	22/45	49	24/99	24	11/16	69	12/15	80	15/21	71
Total	**38**	**1909/3498**	**55**	**349/495**	**71**	**289/521**	**55**	**523/1456**	**36**	**218/308**	**71**	**285/376**	**76**	**245/342**	**72**

G/S – goals in relation to shots

A **conclusion** can be made from this analysis, that the increased number of shots does not result in greater efficiency, or to say it more precisely, hasty shooting is more inefficient! Of course, this situation is influenced by the greater equivalence of the teams participating at the EC.

Table 3: *Shots efficiency of women's teams at the OG – 2012*

Team	Number of matches	Total shots		6 m. shots		Wing shots		9 m. shots		7 m. throws		Fast break		Breakthrough	
		G/S	%	G/S	%	G/S	%	G/S	%	G/S	%	G/S	%	G/S	%
ANG	5	132/235	56	13/26	50	21/30	70	53/120	44	18/24	75	14/16	88	13/19	68
BRA	6	156/271	58	23/27	85	32/55	58	50/129	39	15/19	79	21/22	95	15/19	79
CRO	6	167/262	64	34/48	71	22/38	58	39/83	47	16/23	70	29/34	85	27/36	75
DEN	5	113/235	48	19/23	83	15/31	48	40/119	34	15/21	71	16/28	57	8/13	62
ESP	8	201/348	58	51/75	8	26/46	57	34/104	33	29/43	67	17/25	68	44/55	80
FRA	6	147/285	52	35/51	69	12/26	46	41/128	32	8/12	67	37/47	79	14/21	67
GBR	5	91/204	45	21/27	78	14/35	40	16/79	20	14/20	70	14/20	70	12/23	52
KOR	8	214/398	54	30/45	67	28/51	55	69/176	39	30/47	64	26/37	70	31/42	74
MNE	8	210/358	59	41/55	75	44/71	62	47/125	38	27/32	84	29/40	73	22/35	63
NOR	8	196/380	52	40/62	65	32/48	67	66/177	37	14/25	56	30/44	68	14/24	58
RUS	6	174/293	59	18/23	78	21/45	47	44/117	38	21/26	81	40/48	83	30/34	88
SWE	5	108/229	47	24/33	73	22/45	49	24/99	24	11/16	69	12/15	80	15/21	71
Total	**38**	**1909/3498**	**55**	**349/495**	**71**	**289/521**	**55**	**523/1456**	**36**	**218/308**	**71**	**285/376**	**76**	**245/342**	**72**

G/S – goals in relation to shots

The following differences are established (see table 3 and 4) in the data comparison of shooting from various positions and distances at the OG and EC (table 3 and 4): **1.** At the OG, the 6 meter shooting (from the center 2,3,4 zone) has a higher efficiency – 71% compared to 66% at the EC, as well as in wings shooting – 55% compared to 51%. While at the EC, 9 meter shooting has a higher efficiency – 37% compared to the 36% at the OG, as well as with the 7 meter throws where the efficiency is 75% compared to 71% at the OG; **2.** The fast breaks (FB) were more efficient at the OG – 76% compared to 73% at the EC, while with regard to the Breakthroughs the situation is reversed – the efficiency was higher at the EC – 74% compared to 72% at the OG.

Summary: 1. The most efficient is the shooting in FB and breakthroughs. The efficiency is within the range of 72 – 76%. **2.** Highly efficient is also the shooting in the performance of 7 meter throws. We must underline here that one of the factors for the excellent ranking of Montenegro at the OG (2nd place) and at the EC (the 1st place) was the successful performance of the 7 meter throws of female handball players of Montenegro at the OG – 84% and at the EC – 69%. **3.** The high percentage (71-66) of 6 meter shots efficiency (center 2,3,4 zone) confirms pivot efficiency. **4.** The comparatively lower percentage in shooting from long distance (9-12 m), which is almost equal at the OG and EC (36 и 37 %) emphasizes the need of greater variety of different types of shots, and most of all is emphasized the need of increasing the moment of surprise when shooting.

Table 4: *Shots efficiency of women's teams at the EC – 2012*

Team	**Number of matches**	**6 m. center shots**		**Wing shots**		**9 m. shots**		**7 m. throws**		**Fast break**		**Breakthrough**		**Total**	
		G/S	**%**	**G/S**	**%**	**G/S**	**%**	**G/S**	**%**	**G/S**	**%**	**G/S**	**%**	**G/S**	**%**
CRO	3	15/24	63	15/34	44	16/36	44	7/7	100	9/11	82	3/6	50	65/118	55
CZE	6	24/41	59	36/76	47	37/134	28	18/29	62	12/13	92	19/25	76	146/318	46
DEN	7	28/41	68	34/57	60	59/148	40	27/34	79	39/48	81	30/35	86	217/363	60
ESP	6	39/48	81	37/67	55	32/76	42	19/26	73	18/25	72	8/12	67	153/254	60
FRA	6	18/30	60	15/30	50	44/132	33	20/23	87	25/41	61	18/22	82	140/278	50
GER	6	16/26	62	27/51	53	54/123	44	13/21	62	17/20	85	9/16	56	136/257	53
HUN	8	31/50	62	42/77	55	68/172	40	31/40	78	28/31	90	19/22	86	219/392	56
ISL	3	11/19	58	9/17	53	20/78	26	8/11	73	6/7	86	2/3	67	56/135	41
MKD	3	15/22	68	5/16	31	20/80	25	11/14	79	5/7	71	5/6	83	61/145	42
MNE	8	31/52	60	42/64	66	83/207	40	20/29	69	28/39	72	11/13	85	215/404	53
NOR	8	45/71	63	34/74	46	62/157	39	22/29	76	34/45	76	22/38	58	219/414	53
ROU	6	18/26	69	23/57	40	57/153	37	18/25	72	18/25	72	2/5	40	136/291	47
RUS	7	31/48	65	39/83	47	50/120	42	28/38	74	24/36	67	18/21	86	190/346	55
SRB	8	38/47	81	43/75	57	65/148	44	18/27	67	21/35	60	28/43	65	213/375	57
SWE	6	30/45	67	20/45	44	38/120	32	26/31	84	16/26	62	23/24	96	153/291	53
UKR	3	8/15	53	12/21	57	15/63	24	12/15	80	10/13	77	5/10	50	62/137	45
Total	**47**	**398/605**	**66**	**433/844**	**51**	**720/1947**	**37**	**298/399**	**75**	**310/422**	**73**	**222/301**	**74**	**2381/4518**	**53**

G/S – goals against shots

Note.: The information used in the compilation of the table is taken from EHF [3] and IHF [4]

Offence efficiency in numerical equality (NE), numerical superiority (NS) and numerical minority (NM)

The overall average attack efficiency (table 5) is 43% in the 47 matches conducted at the EC and at the OG (but in 38 matches). Under the conditions of NS, it is 53%, i.e. by 10% higher. An inference can be drawn that the teams have practiced specific tactical interactions for the successful completion of the game in NS. This is also confirmed by the fact that even in NM teams manage to score goals with an efficiency of 37 %.

The following **summary** can be drawn from the data displayed in tables 6 and 7, – final matches between Norway and Montenegro:

1. The team of Montenegro uses "dirty" practices more frequently in defense, which lead to 2-minute suspensions of more handball players. The team has 12 minutes of punishment at the OG and 14 minutes at the EC, while Norway collected 4 minutes for each of the two matches. **2.** At the OG (table 6), the team of Norway demonstrated a higher average efficiency of attacks than the one of Montenegro 47:43%, taking into account that its chief supremacy is in games of numerical equality (NE) 63 compared to 39%. The team of Montenegro gains more obvious advantage in numerical superiority (NS) (40% against 36%), while in numerical minority (NM) it is devastating (50:17%). **3.** At the EC (table 7), the average efficiency is in favour of Montenegro 45:41%. The advantage of Montenegro in NS attacks is absolute – 100% compared to 50, while in NM it is 30:25%. Higher is also their attack efficiency under numerical equality (NE) - 43:40%.

Taking into account that the winner at the OG is the team of Norway, and the one at the EC is the team of Montenegro, we can draw the following **conclusions:**

1. The team efficiency under conditions of NS has the biggest contribution for the wins. The advantage of Norway here (63:39%) is crucial for the winning of the Olympic title. **2.** The team of Montenegro plays more successfully in NS - quite evident advantage at the EC (100:50%) and in NM – strongly emphasized (50:17%); **3.** The team of Norway plays handball in a more technical manner, but the Montenegrin players have a broader scope of "scoring decisions" both in NS and in NM. **4.** The team of Montenegro was much better prepared at the EC than Norway for the realization of its NS on the one hand (by scoring 5 goals out of 5 attacks for 4 minutes (100%) and missed 1 goal), and on the other hand – for the successful opposition in a game with reduced number of team players (received 8 goals, but scored 3 in 14 minutes of the game). The data on the game of Norway in NS during the OG is even more striking – under the conditions of NS (for 12 min.) in the match with Montenegro, Norwegian players scored 8 goals and received 10.

Table 5: *Attack efficiency of women's handball teams participating at the EC – 2012*

Team	Number of matches	Attacks		Attacks superiority		Attacks minority		Position attacks		Attacks QO (quick offence)		Individual FB		Team FB (ECA)	
		G/Att.	%	G/Att.	%	G/Att.	%	G/Att.	%	G/Att.	%	G/Att.	%	G/Att.	%
CRO	3	65/159	41	7/13	54	3/13	23	56/142	39	9/17	53	0/1	0	9/16	56
CZE	6	146/357	41	22/39	56	5/15	33	134/342	39	12/15	80	2/2	100	10/13	77
DEN	7	217/445	49	19/26	73	15/35	43	178/386	46	39/59	66	14/16	88	25/43	58
ESP	6	153/332	46	23/40	57	13/24	54	135/303	45	18/29	62	5/7	71	13/22	59
FRA	6	140/334	42	13/28	46	5/15	33	115/285	40	25/49	51	9/10	90	16/39	41
GER	6	136/310	44	16/31	52	9/27	33	119/283	42	17/27	63	3/3	100	14/24	58
HUN	8	219/483	45	34/64	53	10/25	40	191/437	44	28/46	61	–	–	28/46	61
ISL	3	56/168	33	6/17	35	3/13	23	50/156	32	6/12	50	–	–	6/12	50
MKD	3	61/175	35	7/14	50	2/12	17	56/168	33	5/7	71	¾	75	2/3	67
MNE	8	215/478	45	22/45	49	18/51	35	187/435	43	28/43	65	4/4	100	24/39	62
NOR	8	219/483	45	27/51	53	10/33	30	185/433	43	34/50	68	3/3	100	31/47	66
ROU	6	136/357	38	14/36	39	9/23	39	118/325	36	18/32	56	2/2	100	16/30	53
RUS	7	190/432	44	27/43	63	14/35	40	166/386	43	24/46	52	½	50	23/44	52
SRB	8	213/472	45	23/25	66	15/41	37	192/434	44	21/38	55	4/6	67	17/32	53
SWE	6	153/353	43	11/27	41	7/10	70	137/322	43	16/31	52	6/7	86	10/24	42
UKR	3	62/160	39	9/17	53	7/24	29	52/146	36	10/14	71	3/5	60	7/9	78
Total	**47**	**2381/5498**	**43**	**280/526**	**53**	**145/396**	**37**	**2071/4983**	**42**	**310/515**	**60**	**59/72**	**82**	**251/443**	**57**

G/Att. – goals compared to attacks

Note.: The information used in the compilation of the table is taken from IHF [3]

Table 6: *Attack efficiency in the final match at the OG - 2012 (women) Between NORWAY and MONTENEGRO (26:23)*

Team	Total attacks			Numerical equality NE			Numerical superiority NS			Numerical minority NM		
	Time played	goals/attacks	%	min.	goals/attacks	%	min.	goals/attacks	%	min.	goals/attacks	%
Norway	60	26 / 55	47	44	17 / 27	63	12	8 / 22	36	4	1 / 6	17
Montenegro	60	23 / 53	43	44	11 / 28	39	4	2 / 5	40	12	10 / 20	50

Table 7: *Attack efficiency in the final match at the EC - 2012 (women) Between NORWAY and MONTENEGRO (31:34)*

Team	Total attacks			Numerical equality NE			Numerical superiority NS			Numerical minority NM		
	Time played	goals/attacks	%	Time played	goals/attacks	%	Time played	goals/attacks	%	Time played	goals/attacks	%
Norway	80	31 / 75	41	62	22 / 55	40	14	8 / 16	50	4	1 / 4	25
Montenegro	80	34 / 75	45	62	26 / 60	43	4	5 / 5	100	14	3 / 10	30

Note.: The information used in the compilation of tables 8 and 9 is taken from EHF [3] and IHF [4]

The data analysis of the two most prestigious forums of handball in 2012 provide us with grounds to make the following **summary and recommendations** for the future teaching and coaching practice of handball coaches, the realization of which would enhance playing efficiency (and the better ranking) of their teams.

I. In fast break (FB) and extended counter-attack (ECA): 1. Preferentially usage of fast break by improving individual and group interaction, which requires high-level coactivity between the passing player and the one receiving the ball, in maximum speed and training of final scoring; **2.** Detailed study of "moves", i.e. the probable technical and tactical actions of handball players taking part in FB and ECA with the most rational options for unique ending according to defensive players' number and positions; **3.**Variety of modeling the game situations (2-3 variants) for performance of "fast throw-off".

II. In position attack (PA): 1. The extension of the attack is ensured by the **wings,** which are required to take positions almost in the corners of the court and periodically "rush into" (enter) as a second pivot in order to provoke one-to-one situations from zones that guarantee better shooting efficiency. They have to perform precise and efficient small-angle shots; **2.** According to the new requirements of the competition rules, **pivots** constantly set picks, screen and "detain" one/two defense players at the 6-meter line. We are more and more frequently observing shots from almost impossible situations, after loss of balance, possessing the ball and shooting until the latest moment; **3. Center back, left and right backs** (playmakers) have to attain perfection in jump shots (all variants), hip shooting, overhand shooting from a standing position or while running (shooting from an inconvenient leg, surprising shots from the first or second step, from different positions without evident or obvious preliminary preparation); **4. The game in numerical superiority** has more and more tangible and considerable contribution for winning of the match, where the skills of the team to make use of it appears to be crucial. The realization of this advantage however requires two prerequisites: **first –** learning to perfection of 2-3 combinations (interactions) and **second** – the players should not give cause for the referees to award technical fouls (assault/forceful attack or irregular screening); **5. In the event of player suspension (NM),** the team should predominantly conduct PA with fake attacks for shooting and provoking the opponents to do improper counteractions (leading to suspension); **6.** The inclusion of the **goalkeeper** as the seventh attacker at the end of the game or his/her replacement with another player "joker" in case of a negative result (the opponent leads the game by 1-2 goals), according to tactical interactions trained in advance.

III. When playing in defense: 1. Predominant application of defense systems – 6:0 with constant attack towards the 9 meter line (against the personal opponent) or 3:2:1 (modification to 4:2) involving aggressive coverage of all offenders possessing the ball aiming at hampering and breaking the rhythm of attack. **2. Counter measures planned and trained in advance** for counteraction against FB and QC; **3. Tactical stop** involving technical foul of the player possessing the ball and completing FB with an option to avoid a 7-meter throw and/or a 2-minute suspension; **4. In case of reduced number of team players (NM),** the team should „break" opponent's offence with „light" violations and should set up situations for judging forceful attack. The strive of the defense to "impose" on its opponents unusual for them tactical actions, and to make this as a precondition for seizing the ball or making a foul, is observed as an overall tendency.

In addition to the above summary, we would like to underline two extremely important requirements to coaches working with handball players of age above 16 years (of age): **First –** to guide the players by posts in offence and in defense and to make the substitutions regularly (at the right moment); **Second** – to have the ability "sense" in the most critical moment for taking team time-out, including the recently introduced third team time-out.

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THE INVOLVEMENT OF THE WING PLAYER IN TEAM'S STRATEGY. STUDY OF THE ROMANIAN LEAGUE, WOMEN 2012-2013

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Abstract
Are the wing players enough used in their team's tactical approaches? What is their contribution to the team's success? Do they prefer fast breaks, position shoots, or man to man duels? Is the average scoring good enough? Are they changing often the positions? Are they used to play also without the ball? These are the questions our study will give answers for, based on the game's registrations and statistics from the Romanian League for women, season 2012-2013. Statistics can be very useful, but they also have their degree of subjectivity, if taken out of the context, that's why we have chosen to pay special attention to the best ranked teams(1- 4th, also the teams with participations in Europe Cups) by watching video clips of their games. In the end of the paper, we will compare the wings involvement from the Romanian League with the wings performance from the European Championship Serbia, 2012("Statistical model of the wing player who participated in the Women European Championship, Serbia, 2012", Cristina Vărzaru, Igorov-Bosi Marina, 2013).

Introduction
Over the years, the handball game has become more attractive and spectacular and the level of performance has reached an extremely high limit, as an adjustment of the society's requirement for show. That was possible because of a professional strategy and planning of the specialists (trainers, physical coaches, doctors, statisticians, psychologists) with a big desire for fully exploiting the qualities of their players. The technical-tactical baggage was highly enriched with new elements, the speed and power has grown, the technique is continuously orientated to perfection, the hardness of the contact between players is higher, and the possibility to play 2 or 3 different positions appeared as a consequence of playing without the ball. All this factors couldn't be completed without a great physical preparation.

The modern handball requires a bigger involvement of the wing player as before in the strategic plan of every team, knowing the duties of this position during a game. The line players, including the wings and pivot, are the fastest players of the team. As many fast breaks a team has, as bigger the possibility of winning is, knowing that the easiest way to score goals is during first phase of attack, when the wing is the main character. Also, during the 4^{th} phase of attack, a wing with an impeccable technique, playing without the ball by infiltrating to the 6m line, actively participating to 2:2 or more combination, gives higher possibility to succeed.

Teams like Norway, Denmark, South Korea or France had great results over the years because their trainers has adapt the training methods to the handball reality and found the ways of including all the players with their best performances in the teams strategy. Romania is also fighting hard to be one of those teams and has concern to be aligned to the newest trends of modern handball.

Keywords
Wing player, Romanian handball, statistics

Subjects
The analysis of the wing player of the Romanian League, 2012-2013, based on games statistics and video, will help us create the model of the Romanian wing, and see how far, or by case, how close we are, comparing to the model of the European wing who participated at the last European Championship in Serbia, 2012.

The research contains cumulative statistics of all 110 games played in the Romanian League. 11 teams took part of the competitions and the final ranking was:

1. Oltchim Rm. Valcea
2. HCM Baia Mare
3. Jolidon Cluj
4. HC Zalau
5. HC Dunarea Blaila
6. Corona Brasov
7. HC Roman
8. CSM Bucuresti
9. CSM Ploiesti
10. CSM Craiova
11. HC Danubius Galati.

Collected data

Table nr.1: *The number of goals scored by the wings, the average number of goals and scoring's percentage.*

NR	TEAMS	LW	%	Goals/game	RW	%	Goals/game
1	Oltchim Rm. Valcea	112	78%	5.6	103	77%	5.2
2	HCM Baia Mare	79	69%	2.8	55	70%	4
3	Jolidon Cluj	77	68%	3.8	55	69%	2.8
4	HC Zalau	65	65%	3.3	69	63%	3.5
5	HC Dunarea Braila	40	69%	2	59	66%	3
6	Corona Brasov	75	63%	3.8	75	68%	3.8
7	HCM Roman	37	60%	1.9	48	61%	2.4
8	CSM Bucuresti	30	60%	1.5	102	80%	5.1
9	CSM Ploiesti	39	61%	2	52	60%	2.6
10	CSM Craiova	35	57%	1.8	45	55%	2.2
11	HC Danubius Galati	42	51%	2.1	42	53%	2.1

Legend: LW: total number of goals scored by the players specialized on the left wing position, RW: total number of goals scored by the players specialized on the right wing position, Goals/game: the average number of goals scored per game, %: scoring's percentage.

According to Table nr.1, in the Romanian League, season 2012-2013, the left wing scored 2.8 goals per game and the right wing scored 3,3 goals per game, meaning that in every game, the teams scored with the players specialized on the wing positions an average of 6,1 goals. The average scorings percentage for left wing was 64% and for right wing was 65%.

However, the number of actions that included the wings was bigger, and calculating after the missed shoots, we could see that an average number of actions finalized by the wing players were 9 shoots/game.

CSM Bucureşti, Oltchim Rm.Vâlcea and HCM Baia Mare were the best 3 teams in scoring percentage, while looking at the number of goals scored with the wings per game, top 3 was: Oltchim RM Valcea, with 11 goals/game, Corona Brasov: 8 goals and HC Zalau with 7 goals/game.

In order to get a real image about the wings involvement, we need to take a closer look at how these goals were scored. That we can find in Table nr. 2, which shows us that the Romanian wing preferred to shoot first from the angle. Only HCM Roman has more goals scored after a fast break than from the corner and Corona Brasov with the same number of goals scored from the wing's angle and fast break.

Table nr.2

TEAMS	GOALS(wing)	WING	FB	6M	9M	7M	7M s	TF	AS
Oltchim Rm. Valcea	215	85	78	31	1	20	11	7	27
HCM Baia Mare	134	44	41	16	14	19	11	10	21
Jolidon Cluj	132	60	52	10	4	6	9	9	9
HC Zalau	134	50	46	11	7	20	12	11	10
HC Dunarea Bralia	99	53	37	6	3	-	10	10	8
Corona Brasov	150	65	65	4	-	16	16	8	9
HCM Roman	85	26	47	9	3	-	11	12	8
CSM Bucuresti	132	70	48	10	4	19	10	6	16
CSM Ploiesti	91	50	24	9	5	3	8	10	6
CSM Craiova	80	41	30	7	2	-	8	9	7
HC Danubius Galati	84	45	29	9	1	-	11	13	8

Legend: WING: total number of goals scored from the wing position, FB: fast break, 6M: goals scored from the 6 meters line, 9M: goals scored from the back position, 7M: penalties, 7M s: 7m received, TF: technical faults, AS: assists.

From the wing's position, Oltchim Rm. Vâlcea, CSM Bucureşti and Corona Braşov scored the highest number of goals, while looking at the fast breaks, Oltchim Rm. Vâlcea, Corona Braşov and Jolidon Cluj were best.

However, the number of goals scored from the wing position is higher than in Table nr.2 and that gives us the opportunity to conclude, the wing players were involved also in actions without the ball. By changing positions, other players as the playmaker or the back player, finalized the actions by shooting from the wing's position (Table nr.3).

Table nr.3. *Goals scored from the corner using other players than the wings.*

TEAMS	WING	OTHERS
Oltchim Rm. Valcea	85	16
HCM Baia Mare	44	15
Jolidon Cluj	69	14
HC Zalau	50	15
HC Dunarea Braila	53	10
Corona Brasov	65	23
HCM Roman	26	10
CSM Bucuresti	70	33
CSM Ploiesti	50	10
CSM Craiova	41	7
HC Danubius Galati	45	12

Legend: WING: total number of goals scored by the players specialized on the wing position; OTHER: total number of goals scored from the wing's position by playmaker, backs or pivot.

Table nr.4 *Comparison between the Romanian wing and the European wing.*

	%	Goals/game	Shoots/game	WING	FB	OTHER
Romanian Wing	65	6,1	9,5	3	2,3	0,8
European Wing	59	7,1	12	3,7	2,5	0,9

Legend: %: scoring percent; WING: number of goals scored per game from the wing position; FB: number of goals scored per game after a fast break; OTHER: number of goals scored per game from other positions.

Conclusion

By far, in the Romanian League, Oltchim Rm. Valcea had the best wings from all teams and the biggest involvement in their team's strategy. It is not a coincidence that this team had absolutely no problem in winning our league with a big difference of points. Vâlcea's wings are also the wings of the Romanian national team. Comparing the Romanian wing with the European wing, we can conclude that the Romanian wing had a better scoring percent, while the European wing was more involved in the team's strategy, scoring with 1 goal more per game. Like the European wing, the Romanian wing preferred also to shoot most from the wing position and fast break. The second position from where the Romanian wings finalized their action was the pivot, as well as the European wing.

The study shows that the Romanian handball is on track, looking at the involvement of the wing players in their team's strategy. There is, of course, place for improvement and we should also take into consideration the big difference between the schedules of the games. In the Romanian league, there is 1 game per week, and that means a lot of time to recover and prepare the next game, while during an European Championship, one team that reaches the semifinals, has to play 8 games in 14 days. But looking at the place Romania has in the European ranking, and the difference we pointed between the Romanian wing and the European wing, we can conclude that other parts of the Romanian handball needs to be looked more closely.

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OPTIMIZATION PROCESSES IN THE PREPARATION OF FEMALE HANDBALL PLAYERS

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Summary
Handball today is characterized by continuous intensification of the offensive and defensive game situations. A focus on increasing the efficiency of the training process is in the basis of this activity.

In essence, this task is solved in a consistent manner by defining the mechanisms of optimization processes in the training of female handball players. Therefore an understanding of the structure of shooting from a sports, pedagogic and biomechanical perspective would help improve the technique of throwing and the methodology of teaching.

A series of relevant studies exist (Taborsky, F., 1989; Wit, A., Eliasz, J., 1998, Ivancević, V., 2006 , Jotov I., Arakchijski H., 2007, etc.). which, however, do not offer methodological solutions to optimize the training of female handball players. The present study aims to determine the effect of various ways of putting the ball forward in the preparatory stage (reverse hook) on the velocity of the throw, with a view to optimizing the methodology of teaching .

Tasks

1. Study time, distance and velocity parameters in the various types of throw.
2. Study of the internal phase structure of the throw.
3. Testing a methodology for the formation of motor habits in throwing.

Methodology
The focus of research were throws above the shoulder from a standing position performed by two elite players from the Republic of Serbia: Ivana Filipovic (20 years old) height 187 cm, weight 74 kg and Dusan Ilic (27 years old), height 193 cm and weight 87 kg, in four variants.

1. Direct option - reverse hook is carried out in the shortest way
2. With a leading elbow - the reverse hook is performed with a leading elbow
3. With ½ semicircle – in reverse hook the arm with the ball moves at hip height and above it.
4. The long way – the hand with the ball is almost fully unfolded as it moves downward and backward

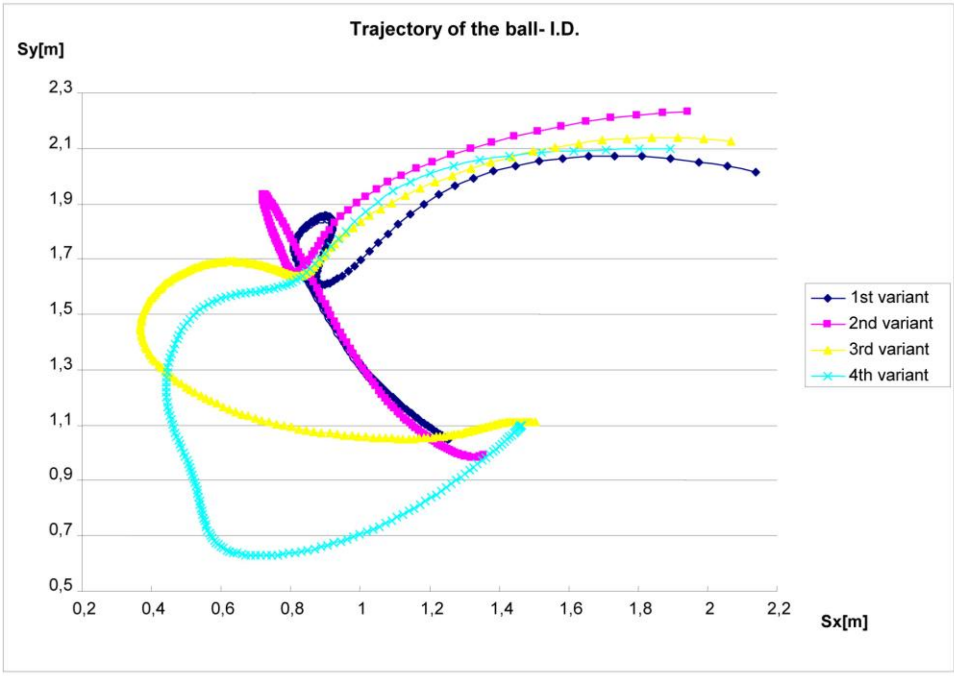
Movement was recorded using a video camera with a motion at 300 fps. The data were processed using our own author video computer system (1). For the purpose of a comprehensive analysis 10 performances were selected for each technique.

The methodology of forming a motor ball throwing habit was elaborated based on a cybernetic model developed by us as well as on the hierarchical model of diversely specialized exercises. The experiment was conducted in the representative team of the Bucky Handball Club - Gabrovo, with 15 to 16-year-old girls over a period of three months.

Analysis of results

Figs 1a and b show the trajectories of the ball in the various versions of the throw.
It is noteworthy that all four ways of the forward movement of the ball differ substantially. Differences are observed mainly in the implementation of the whiplash movement. In the second swing (acceleration), the effort is smoothly distributed so that almost no changes are observed in the direction of the trajectories in all four cases.

a



b

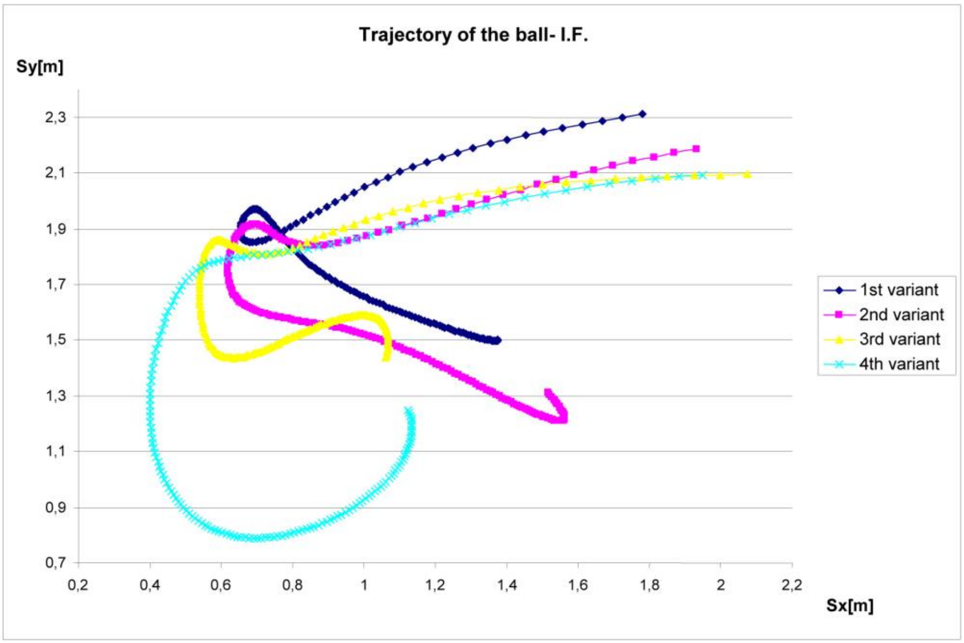


Fig.1
Trajectory of the ball – I.D (a) and I.F (b)

Table 1 shows that the time for implementing the throws ranges from 0.57 sec to 0.71 sec with player I.F., while with player I.D. it is in the range of 0.60 sec to 0.77 sec. It can be noted that in both respondents the time for implementing the throws is the shortest in the performance of shooting in the long way in the preparatory phase. The analysis of the trajectories reveals that the movement of the ball at all times is performed in a very elegant manner without departing from the direction.

Table *1*_Time, Distance and Velocity parameters in the different scenarios of throw with one hand above shoulder_

Type of shoot / Indicators		Time			Distance			Velocity	
		T_{total}	Dt_1	Dt_2	S_{totalo}	S_1	S_2	V, m/s	V, km/h
Direct	I.F.	0,57	0,41	0,16	2,27	0,95	1,32	17,89	64,40
	I.D.	0,68	0,56	0,12	2,77	1,23	1,54	24,72	88,99
With leading elbow	I.F.	0,71	0,47	0,24	2,82	1,25	1,57	19,10	68,80
	I.D.	0,77	0,36	0,41	2,91	1,20	1,71	22,11	79,60
With semicircle and ½ semicircle	I.F.	0,58	0,37	0,21	2,69	0,88	1,81	22,85	82,30
	I.D.	0,77	0,33	0,44	3,39	1,33	2,06	23,90	86,04
The long way	I.F.	0,55	0,34	0,21	3,38	1,33	2,05	22,46	80,90
	I.D.	0,60	0,39	0,21	3,59	1,64	1,95	28,30	101,90
Mean value	I.F.	0,60	0,40	0,20	2,79	1,10	1,69	20,56	74,10
	I.D.	0,71	0,41	0,30	3,17	1,35	1,81	24,76	89,13

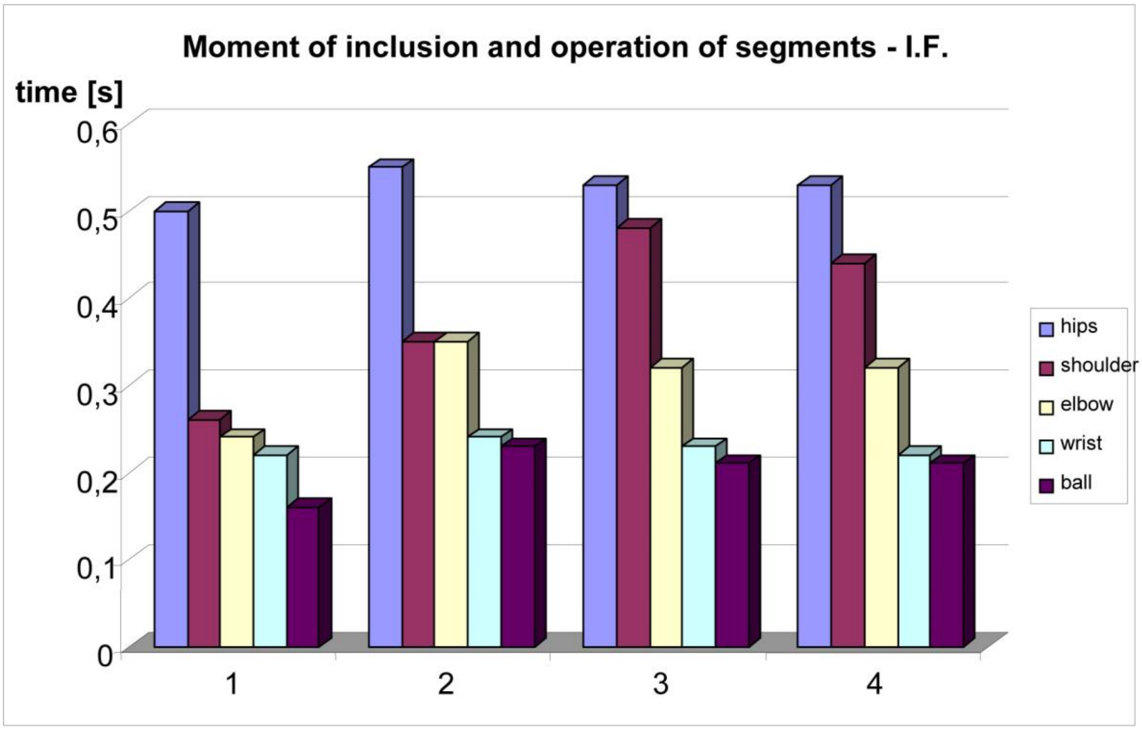
Odometry results show that distance is 2.27 m with I.F. and 2.77 with ID in performing the throw in the direct option while in the long-way it is 3.38 and 3.59 m respectively. The inter-phase structure of parameters of Δt (time for implementation of preparatory phase (Δt1) and Δt2 (time for implementation of the second swing (acceleration) vary considerably. Δt1 is usually longer, the only exception registered has been with I.D. in performing a throw with a leading elbow with ½ semicircle.

The highest velocity values are measured with I.D. at throwing the long way V = 101,90 km/h and with I.F. in the ½ semicircle where V = 82,30 km/h.

Fig. 2 illustrates the sequence of inclusion of the individual segments, the reading starts from the moment of the movement of the segment in the direction of the target. It is noteworthy that these structures differ in the cases studied.

Fig. 3 illustrates peak velocity values Vh in different units of the kinematic handball - ball chain. The results show the distribution of the force effort both by amplitude and in time.

a



b

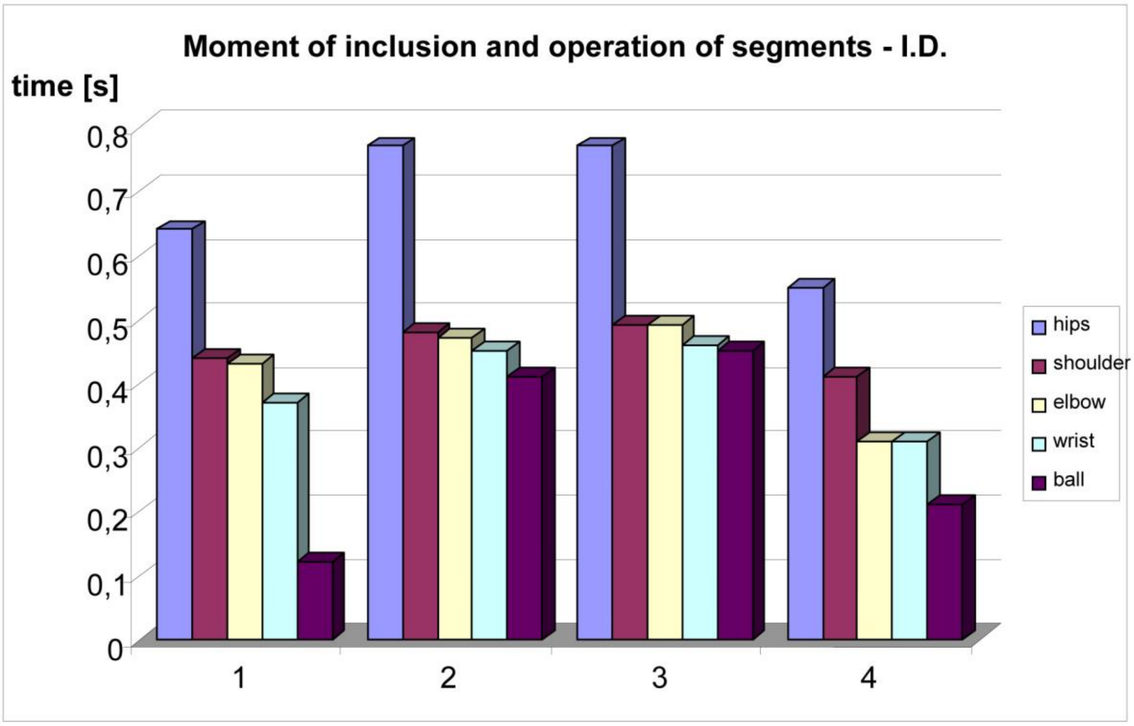
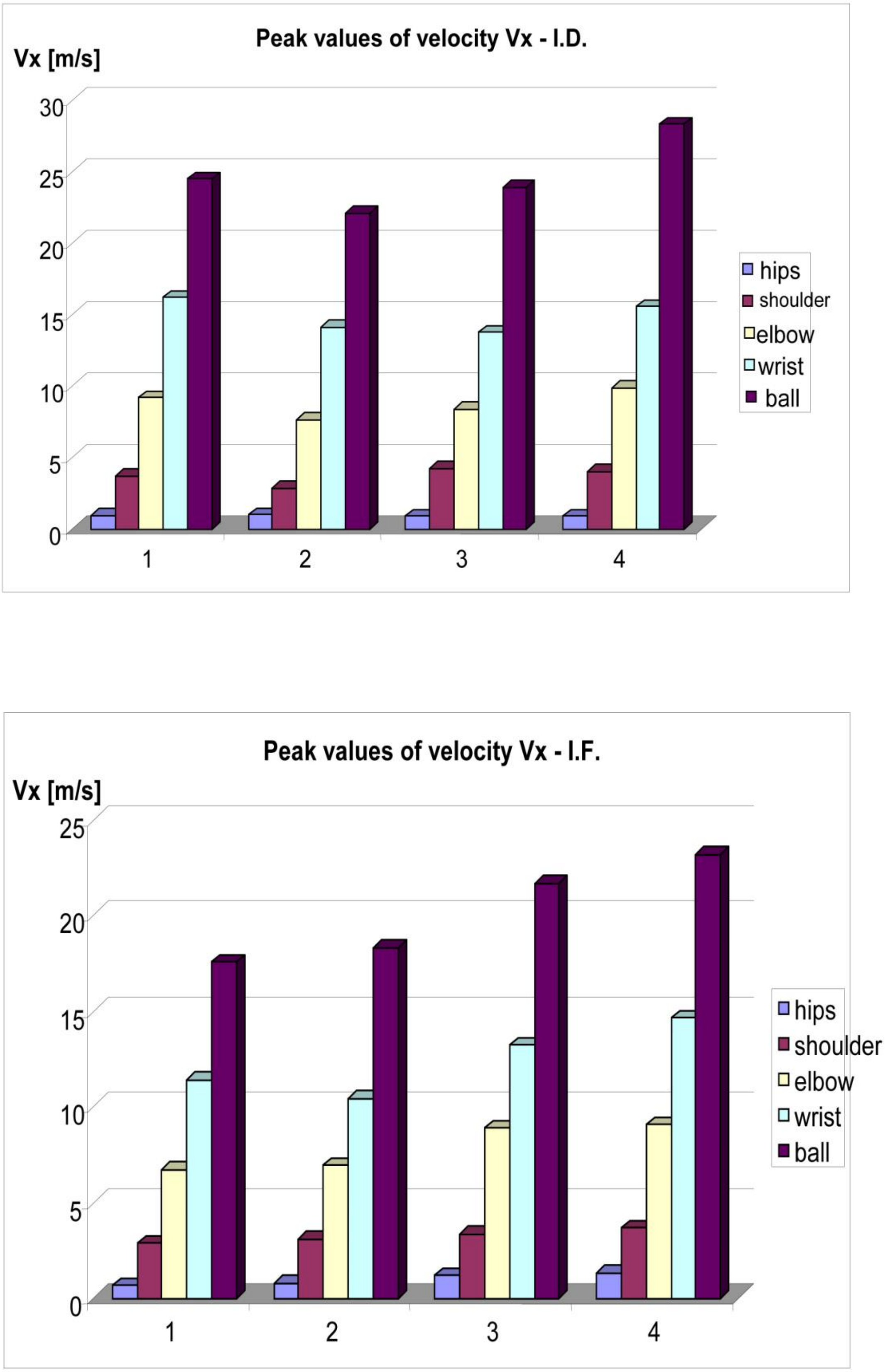


Fig. 2
Moment of inclusion and operation of the segments – I.D. (a) and I.F. (b)

a



b

Fig. 3

Peak values of Vx – I.D. (a) and I.F.(b)

Methodology of teaching

Table 2: *Phase structure of self-learning system*

FORMS OF LEARNING	STARTING POINTS	TRAINING ENVIRONMENT	TRANSITIONS	ACHIEVED GOALS
I. STAGE Elaboration of an initial program for the management of the motor action				
1.Training through instruction	Lack of management program	Instructions and Descriptions of motor action	Verbal modeling of management program	Initial Management Program
2. Training through demonstration	Lack of management program	Demonstration of motor action	Visual modeling of management program	Initial Management Program
3. Training through manipulative impact	Lack of management program	Manipulative impact on trainee	Kinesthetic modeling of management program	Initial Management Program
II. STAGE Refinement of the program for management of the motor function				
1. Training through understanding	Initial Management Program	Explication by the teacher and meaningful exercise by student	Rational adjustments to the management program	Precise unsustainable management program
2. Training through standard drill	Initial Management Program	Independent standard exercise	Kinesthetic corrections to management program	Precise unsustainable management program
3. Training through intermodal exercise	Initial Management Program	Independent intermodal exercise	Visual corrections to management program	Precise unsustainable management program
III. STAGE Stabilization of program for management of stereotyped motor actions or reaching a position for instant modification of the program for management of game motor actions in accordance with the situation				
1. Training through memorizing	Precise unsustainable management program	Stereotyped exercise with maximum intensity	Memorizing the program for management	Consolidated management program of the motor action
2. Training through placement in a conditional agreement	Precise unsustainable management program	Training of exercise complexes upon alerts	Modeling of program for management on alerts	Conditional memorized program for management of a series of exercises upon alerts
3. Training through game	Precise unsustainable management program	Exercise of motor actions in game conditions	Visual modeling of management program	Situationally changeable program for the management of game actions

Factors influencing the teaching methodology in whip-throwing are:

- *Genotypic:*
  - breadth of the hand span;
  - length of the hand span ;
  - develop coordination skills ;
  - flexibility
- *Phenotypic.*

These are related to implementing the cybernetic model of learning the whip throw. Transformation of the self study system is the result of information generated by it. The transitions through which the conversion of the system is carried out are distinguished from one another by the nature of the received data. The main channels are the sensory organs and the perception of verbal information. **Table 2** shows the phase structure. The implementation of the phase structure of the motor habit is carried out through the application of the hierarchical model of diverse specialized handball exercises and speeds up technical training.

Level I (specialized exercises) . This includes the implementation of the shots in the goal after individual, group or team activities in the presence of opposition by the defense. The psychological nature of competitive environment is fully retained See **Fig. 4**:

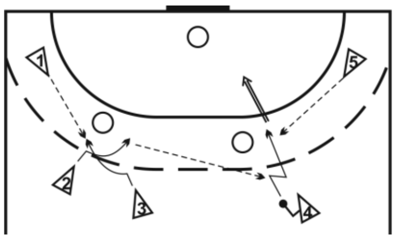


Fig. 4

Shooting from the position of the back after crossing (1 – 3 + 2 – 4 shot)

Level II (specialized exercises) . These include throws and passes with change in weight and circumference of the ball, changing the angle of rebound, with contrasting changes in overcoming resistance to focus on different body parts. Examples:

- ***Standard exercise***
  - *First exercise.* Exercise of catching and submission in pairs at a distance of 6-8 m.
  - *Second exercise.* Shooting from standing position in the handball goal (no goalkeeper) from distance of 8-9 m. The ball is reduced in size - 22-24 cm, 200 g.
  - *Third exercise.* Passing the ball in pairs at a distance of 8-10 m (the technique of swing in the preparation of the whip throw is changed in successive series)
  - *Fourth exercise.* Shooting in the goal with a goalkeeper. Frontal shots are performed after three enhancing steps from a distance of 8-9 m. It is required for the player to target the ball into the open corner of the goal, depending on the location and the response of the goalkeeper.

Variational exercise

Variability in the performance of whip-throws is implemented in the execution of the first swing and directing the ball into the following combination (see methodology 4, 3, 2, 1), which is also the teaching methodology sequence.

Level III (auxiliary exercises). Includes all technical, power and tactical preparatory exercises. These exercises have a local, regional or global effect; their dynamics and kinematics must conform to a certain degree to the primary (competitive) exercise. For proper execution the following approach is to be adopted:

1. *Additional instruction* - it is pointed out that the most important thing during the first swing is the backward and upward movement of the elbow of the shooting arm
2. *Manual impact* (direct assistance with one's hands):
   - fosters the implementation of the hand with the ball in the swing phase through removal (abduction) and pronation;
   - fosters the implementation of the whip throw, in which the elbow is ahead of the hand holding the ball

As a result of the exercise of whip throw an initial program for management of the whip throw is built, allowing for the rough execution of the movement. The results of the experiment are presented in **Table 3** and **Fig. 5** . The resulting values are quoted in degrees (°)

Fig. 3

Peak values of Vx – I.D. (a) and I.F.(b)

№	Name and surname	I measurement	II measurement	Difference
1	B.G.	52°	75°	23°
2	S.I.	49°	70°	21°
3	L.K.	54°	69°	15°
4	S.V.	56°	72°	16°
5	M.K.	53°	67°	14°
6	D.K.	50°	65°	15°

Pedagogical experiment to optimize the throwing technique

Summary

Based on the performances of shots with one hand over the shoulder from a standing position analyzed above, we can say that in the four variants of the shooting there is a difference in timing, distance traveled, velocity, as well as in the internal phase structure of the various moments of inclusion and operation of a given segment. The latter considerably influences the specific rhythm in individual performances. This is an important prerequisite for the optimization of the methodology of training the whip throw. The conducted pedagogical experiment proves the efficiency of the employed methodology on increasing the size and amplitude in the execution of a whip throw.

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THE ANALYSIS OF THE EFFECTIVENESS OF 7-METRE IN HANDBALL: STUDY CONDUCTED IN THE WOMEN'S COMPETITION OF THE LONDON OLYMPIC GAMES 2012

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Summary
This article presents the results of the to analyze how seven meters shots have been performed during the women's competition of the London Olympic Games 2012. Our sample was composed by 204 7m shots. Teams have more success in shooting 7 m when they are losing then when they are winning the game.

Introduction
Goals from 7-Meter shots are one of the ways that teams more seek as a way of finalizing an attack because its high level of efficiency compared to other forms of finalizing. In women's handball that has been relevant in the last years. During the women's competition of the London Olympic Games 2012, total goals thus obtained was 218 which accounted for 11.42% of the total goals of the competition (IHF, 2013).

With this work we intended to analyze how seven meters shots have been performed in this competition and try to relate them to their effectiveness. We took into account the march of the game result, the time line, and the effectiveness.

Material and methods
The instrument we used for the analysis of seven meters was the videobserver© (Afra, 2013). The data was digitized using the program Microsoft Excel, then imported and analyzed with SPSS 18.
Sample
The sample consisted of a total of 204 7m shots.
Procedures
We used the following procedures for analyzing the 7 meters: Recording Game ;Load the game on the platform Videobserver; Create a team on the platform; Create players of each team; Create the game on the platform; Add the video to the created game; Analyzing process of the videos; Analysis of tables; Sum of the actions of the 204 7m.

Presentation and discussion of results
Goals through 7 meters concerning the game result - by Team.

Table 1 - *Goals through 7 meters concerning the game result - by Team*

TEAM	Sweden			Korea			Spain			France			Norway			Denmark		
RESULT	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss
7M	9			19			19			6			9			2		
%	0	22	78	68	16	16	11	37	53	67	0	33	11	44	44	50	0	50

TEAM	Brasil			Angola			Great Britain			Russia			Montenegro			Croatia		
RESULT	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss
7M	10			16			12			17			17			11		
%	60	10	30	75	0	25	17	0	83	71	6	24	29	18	53	45	27	27

As we can see through Table 1, 5 of the 12 teams scored more 7meters when they were losing then when they were winning. Denmark scored 50% of the 7meter goals when winning and when losing. The other 6 teams scored more when they were winning then when they were losing.

From the 4 teams that reached the finals (Norway, Montenegro, Spain and Korea), only Korea was more efficient scoring 7m when winning then when losing. The other 3 were always more efficient when losing then when winning. Maybe when teams are losing they feel more the responsibility of shooting a 7m then when winning a game.

Failed 7 meters concerning the game result - by Team.

Table 2 - *Failed 7 meters concerning the game result - by Team*

TEAM	Sweden			Korea			Spain			France			Norway			Denmark		
RESULT	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss
7M	3			10			9			4			5			3		
%	33	0	67	50	20	30	78	0	22	50	25	25	20	20	60	0	33	67

TEAM	Brasil			Angola			Great Britain			Russia			Montenegro			Croatia		
RESULT	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss
7M	4			6			3			5			2			3		
%	25	0	75	17	0	83	67	0	33	40	0	60	0	0	100	0	0	100

8 teams failed more 7 meters when they were losing the game. The other 4 were less efficient when they were winning the game.
Also in this case seems that the responsibility of shooting a 7m in a losing position could be an explanation of our results.

Total percentage of 7 meters - by Team

Table 3 - *Total percentage of 7 meters - by Team*

TEAM	Sweden			Korea			Spain			France			Norway			Denmark		
RESULT	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss
ALL 7M	1	2	9	18	5	6	9	7	12	6	1	3	2	5	7	1	1	3
%	8	17	75	62	17	21	32	25	43	60	10	30	14	36	50	20	20	60

TEAM	Brasil			Angola			Great Britain			Russia			Montenegro			Croatia		
RESULT	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss	Win	Tie	Loss
ALL 7M	7	1	6	13	0	9	4	0	11	14	1	7	5	3	11	5	3	6
%	50	7	43	59	0	41	27	0	73	64	5	32	26	16	58	36	21	43

When we analyze the total of 7m that every team had during their games (table 3) we find out that half of the teams shoot more 7m when losing and the other half shoot more 7m when winning. Also when comparing the best 4 teams in this tournament, the first two (Norway and Montenegro) had more 7m when losing then when winning and the other two teams (3th place Spain and 4th place Korea) had more 7m when winning then when they were losing.

Table 4 – *Total of 7meters of all teams*

TOTAL 204 –7 Meters			
	Win	Tie	Loss
7M	85	29	90
%	**42**	**14**	**44**

If we look to the Table 4 we find out that there is almost a tie between the shooting of 7m when the teams where winning and losing (42% against 44%).

Conclusion

It seems that result evolution during the game has a positive or a negative effect in the 7m shooting effectiveness. Most of the teams (8) are less efficient when they are losing the game but all the teams score more goals through 7m then fail 7m.

For the coaches it seems important to understand when and why his team is more less efficient when shooting 7m. This first results must be crossed with variables like the 7-M Shooter, their handedness (right-handed or left-handed), the point of entry of the ball in the goal and the place where the goalkeeper stands because in this way the coach will have better date when he needs to decide who should shoot the next 7m or which Goalkeeper should he choose at a certain moment against a certain shooter.

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BEACH HANDBALL TO IMPROVE JUMPING POWER

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Summary
The aim of this study was to determine the effects of beach handball on explosive strength indicators in adult handball players. This study was carried out during the beach handball season in Spain. Our results show that beach handball has no significant effects in men handball players but have significant effects improving the explosive strength in women.

Keywords
Beach handball, explosive strength, training, off-season period

Introduction
The off-season is the period between the last competition period and the first period of the next year's season. The length of time recommended for the off-season period should provide enough time to recover for next season (Baechle TR, Earle RW, 2008). When reduced volume or intensity training occurs it is called detraining , defined as cessation of exercise training, and is a deconditioning process that affects performance due to diminished physiological capacity (Fleck SJ, Kraemer WJ, 2004).

Supporting literature says that moderate cessation training involves a decrease in submaximal strength and a small decrease in maximal force and maximal power. This detrimental effect depends upon the duration of training cessation, age and training level, but is not influenced by sex or the characteristic of previous training (Bosquet L, et al. 2013; Mujika I, Padilla S, 2001).

Oliveira (Oliveira VdL, et al., 2009) studied the behaviour of neuromuscular variables after 40 detraining days and concluded that a decrease of lower body coordinative capacities exists in this detraining period. Not only there was a registered decrease in strength and coordinative capacity, Ormsbee (Ormsbee MJ, Arciero PJ, 2012) also found adverse effects in body composition, fitness and metabolism in swimmers.

Handball players normally participate in off-season training that requires different activities for maintaining physical condition. Professional players utilize the off-season to improve their capacities (hypertrophy) but some players practice beach handball in summer time. Beach Handball is a modality similar to indoor handball except it is played in the sand. This decreases articular impact and injury risk due to the absence of physical contact. Sprinting in the sand surface decreases the velocity of men by 15.5% on average and by 12.4% in women compared to the average velocity of an athlete sprinting on a track (Alcazar PE, et al., 2011). But Beach Handball requires vigorous activity and has a constant heart registration of 80-83% HRmax (Lara D, 2012) and lactate concentrations (Güzel NA, Eler S., 2003) 4.07±0,6 mmol/L to 6.05±1,3 mmol/L defining an anaerobic sport property.

Therefore, the first aim of this paper is to determine the effects of beach handball on explosive strength indicators in adult handball players. The second aim is to compare a group of handball players who perform beach handball off season to handball players who perform other sports not related to handball.

Methods

Subjects

The study included 23 non-professional players divided into two groups, one experimental group and one control group. The first group plays beach handball during the indoor handball off-season and the other group participates in sports such as running, fitness or padel. The 13 players from the experimental group completed the beach handball season with a great number of matches and the control group of 10 players didn't participate in the beach season. The beach handball season in Spain starts in May and ends in early August when players begin the pre-season period in court handball.

The experimental group consisted of 6 men and 7 women, all with the same years of training and tournament experience in indoor handball from June to August, 2013.

The control group consisted of indoor players, 5 men and 5 women. In the off-season this group plays other sports unrelated to handball like running, bicycling or padel. The subjects answered a questionnaire explaining all the activities from the summer period.

	Beach Handball Group	Control Group
N	13	10
Age (yr)	22,92±4,75	23,20±3,71
Height (cm)	175,69±11,12	172,00±7,15
Men/Women	6/7	5/5
Body mass(kg)	69,08±15,11	74,50±13,80
Body fat (%)	♂ 13,83±1,94 ♀21,29±5,59	♂ 17,60±4,83 ♀29,00±7,71

The level of performance

All subjects were measured based on explosive force (heigh) and power (Peak Power) of the lower limb by performing the Counter Movement Jump (CMJ) and Abalakov Jump (ABK) test using force platform Quattro Jump (Kistler, Switzerland).

The jump test is based on a total of two jumps to calculate maximum height. Hands are positioned at the hip for CMJ, starting from a standing position and utilizing the arms moving for jumping higher in ABK.

The anthropometric variables studied were height, body mass and body fat percentage. In order to measure the anthropometric parameters, the standardized techniques were followed as recommended by the International Society for the Advancement of Kinanthropometry.

Experimental Design

To examine the influence of beach handball in the off-season period, the players were divided into two groups. The beach handball group performed a mean of 20 training sessions in beach handball and 20 matches in a 2 month period (June-August). The control group self-recorded a mean of 3 days a week of physical activity.

Jumping ability as a predictor of Explosive Strength (CMJ and ABK) at the start of the beach handball season and of the following season of court handball was assessed. The evolution of explosive strength can also be observed in this research. In order to assess the frequency and intensity of physical activity, a questionnaire was given to the participants.

Statistical Analysis

To address the problem, the effects and the percentage changes of each experimental group were evaluated. Before applying parametric techniques to the data, the normal distribution assumptions were confirmed by using Kolmogorov-Smirnov test and normal probability plot. If those assumptions were not valid, nonparametric (distribution-free) tests were used.

First, descriptive statistical data of continuous variables were presented as the mean and standard deviation. Change form baseline to follow-up the group was tested using Wilconxon test (Paired Test) to confirm their significance. The p≤0.05 criterion was used to establish statistical significance.

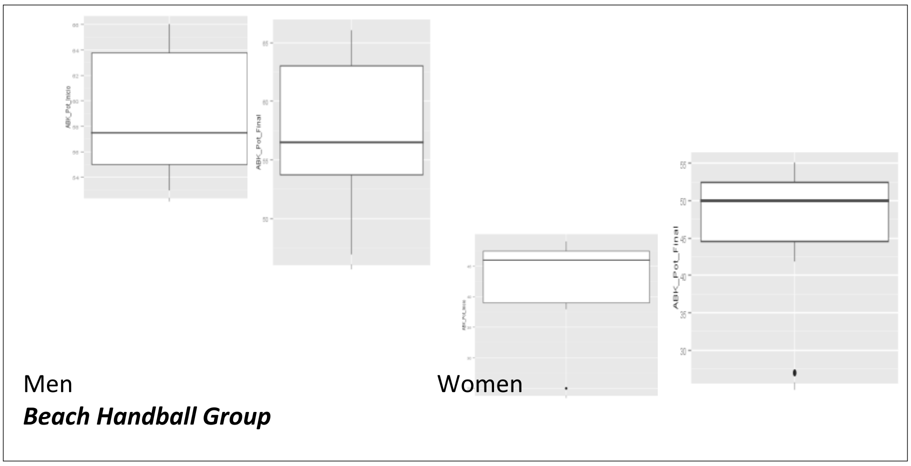
Statistical analyses were performed with the help of "Deducer R; Java Gui for R (Version:1.7-11)" Software Free.

Results

The average changes in the explosive test performances in CMJ and ABK were measured in cm (Heigh) and Peak Power in CMJ and ABK; in the Beach Handball Group the CMJ_Heigh in men decreased by 6% but in women no changes were registered. ABK_Heigh in men decreased by 4% but in women increased by 9%, CMJ_Peak Power decreased by 2% in men and in women increased by 3%. ABK_Peak Power decreased by 1% in men but in women increased by 11%. The control group registered no significant effects in all variables.

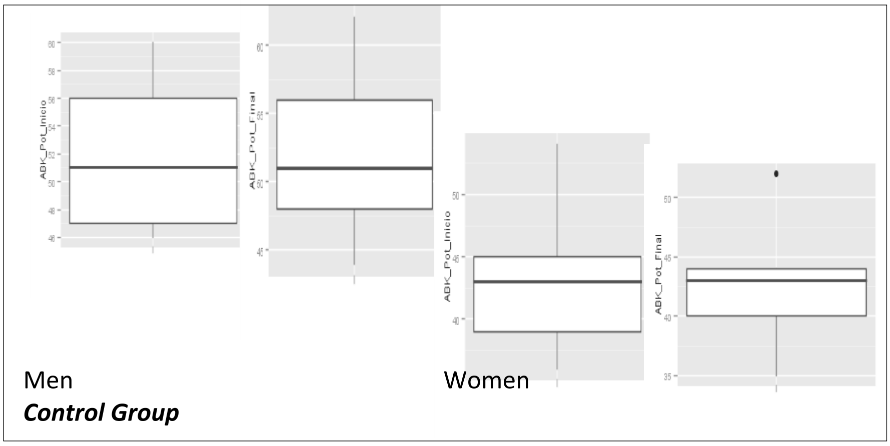
Table 2.- *Values and means ± SD, N=23*

Variables		Beach Handball Group		Control Group	
		Men	Women	Men	Women
CMJ (Heigh)	Before	50,50±10,01	33,71±4,50	42,80±7,66	32,40±4,28
	After	46,67±3,44 †	33,86±3,93 †	42,00±9,30 †	32,00±4,00 †
Abalakov (Heigh)	Before	60,17±11,81	38,57±7,93	49,40±8,65	38,40±6,31
	After	57,17±10,42 †	**41,86±8,34 ‡**	49,80±9,15 †	38,60±5,55†
CMJ (PeakPower)	Before	50,33±4,72	38,43±4,35	46,60±7,67	39,40±4,45
	After	49,17±3,97 †	39,29±3,25 †	46,00±6,86 †	38,20±4,82 ‡
Abalakov (PeakPower)	Before	59,00±5,55	41,86±8,51	52,00±5,96	43,40±6,88
	After	57,33±7,23 †	**46,57±9,64 ‡**	52,20±7,01 †	42,80±6,22 †
CMJ.- Counter Movement Jump ; ABK.- Abalakov Jump: † Magnitudes do not show differences from preceding test ‡ Magnitudes show differences from preceding test					



Graphic 1.

The graphic shows the Peak Power of Abalakov Jump in men and women in the beach handball group. The difference between pre-post in men's group is not significant but the difference is significant in women with an improvement in 4.714 with p-value of 0.047<0.05



Graphic 2. *The graphic shows the Peak Power of Abalakov Jump in men and women in the control group*

Discussion

This is the first study to document the relationships between beach handball and strength power for controlling detraining effects. The primary findings of the present study demonstrated that beach handball is just a valid of a solution to maintaining physiological performance as practicing a different sport.

Different responses occur in female athletes, mainly showing an increase in both tests but statistically significant in the Abalakov Peak_power test. That means that in women, beach handball is a stimulus. This conclusion is related to studies that assess the effect of plyometric training on sand (Impellizzeri FM, et al., 2008), reporting an improvement in jumping and sprinting ability and decreased muscle soreness.

This study is similar to Santo's studies in basketball players (Santos EJ, Janeira MA, 2009; 2011). This author compares the effects of detraining and of a reduced training program in basketball players and concluded that regular practice alone can sustain previously achieved explosive gains. These results reaffirm that specific training maintains athletic performance.

Another study found that a 3 week reduced training program has no significant effects on soccer players running the 20-metre sprint compared to a running program, plyometric training program and rest (Nakamura D, et al., 2012).

Limitations

Although these results do not support complete inactivity during the off-season period in the control group and date evaluation was not totally adjusted to the beach handball season in the intervention group, we find evidence to continue investigating not only in explosive strength effects but also in coordinative capacity.

Conclusions

In summary, we found that beach handball has significant effects on the improvement of explosive strength in women but has no significant effects in male handball players. The result of this study may be useful for handball players and their coaches in terms of managing the off-season period. Beach handball is a good activity to perform in off-season period to fight against the effects of cessation training when the season is finished.

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THE USE OF INFORMATION TECHNOLOGY IN NON-FORMAL EDUCATION AND INFORMAL LEARNING OF HANDBALL COACHES

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Summary
The article presents the results of the research about the use of information technologies in non-formal education and informal learning among handball coaches in the Czech Republic. We show what forms and methods of ICT they use and in which languages. Differences between male and female coaches will be mentioned, where women are more satisfied with available sources and discuss more issues related to coaching through ICT.

Keywords
Coach education, empirical research, Information and Communication Technology (ICT), one-way communication, two-way communication

Introduction

The development of the coaching profession has recently increased its attention (Jansa, Dovalil 2009; Sekot 2006; Trudel , Gilbert 2006) and some results of empirical research have been published in this area (Jansa, Kovář 2008; Lavallee 2006).

Information and Communication Technologies (ICT) play an increasingly important role in the gradation of a coaching profession. Our empirical research targets this area, specifically questions about the use of ICT in non-formal education and informal learning among handball coaches. Specific forms and methods of the use of information technologies (video channels, social network, electronic databases, websites, computer programmes, smart phones, etc.) were to analyze in non-formal education and informal learning of coaches concerning this empirical research.

Methods

The research had two phases, a quantitative and a qualitative one.

In the period from January to July 2013 a questionnaire survey was carried out. We designed our own questionnaire which was used and distributed electronically through authorized persons by email or delivered personally in a printed form. The aim of the survey was to obtain an overview of selected aspects of the use of information technology in non-formal education and informal learning among coaches of different sports.

Overall, there were 85 returned and completed questionnaires, the observed characteristics of the study sample are shown in the Table 1. The most represented group of respondents consisted of coaches -men (80%), the average age was 41 years (the youngest one - 19 years old , the oldest one - 67 years old) and the largest group consisted of 31-45 years old coaches (48 %), the majority of these are coaches (52%) who work in cities with over 100,000 inhabitants, more than half of the respondents have completed high school education (62%), 7% graduated from universities with a focus on sport (sports-related). Most respondents (48%) hold a B license (second level). Most of these respondents are volunteers (59%), 27% are semi-professional coaches and 14% professional ones. Head coaches (69%) dominate among these respondents, 14% act as assistants, 14% as team leaders and the rest (39%) act at a different position. Almost two thirds (50%) work with children or youth, 11% work with adults and 25% with both age groups. Most coaches work with boys (48%), 28% of coaches work with girls and 24% with both sexes.

We are fully aware of the relatively low number of survey respondents, that is why we do not want to generalize the results of this survey to the entire group of handball coaches in the Czech Republic and all the results are presented in percentage terms.

Table 1: *Characteristics of the study sample (indicated in percentage, N = 85)*

Sex	Men	80
	Women	20
Age	18-30 years	16
	31-45 years	48
	46-60 years	31
	61 years and over	5
Size of an Area Covered by a Coach	A city over 100 000 inhabitants	52
	A city from 2 000 to 99 999 inhabitants	15
	A village up to 1 999 inhabitants	33
Highest Level of Education	Primary	7
	Secondary	62
	Postsecondary - vocational	5
	Higher – no sport-related university degree	19
	Higher – sport-related university degree	7
Coaching Career	A-License (1st level)	12
	B- License (2nd level)	48
	C-License (3rd level)	40
	Lower or unlicensed	0
Professional Coaching Experience	Professional	14
	Semi- Professional	27
	Volunteer	59
Coaching Position	Head Coach	69
	Assistant	14
	Team Leader	14
	Another position	3
Trained Sportsmen - Distribution by Age	Children and youth	64
	Adults	11
	Different age groups	25
Trained Sportsmen - Distribution by Sex	Girls/women only	28
	Boys/men	48
	Girls/women and boys /men	24

In the second phase, three selected coaches were interviewed. Selection of trainers was deliberate, three experienced coaching personalities of handball were chosen, this was the most represented sector among respondents. Dušan Poloz – 2012/2013 Czech champion with a women's team DHK Banik Most, head coach of women's representation in Slovakia, Jaroslav Hudeček – men's national coach of the Czech Republic, Jana Hajžmanová – longtime coach of youth teams HC Banik Karvina (they became champions of the Czech Republic several times). The purpose of these interviews was to clarify opinions and attitudes on selected topics from the first phase.

Results

In the survey , coaches commented on the use of different information sources through ICT. These coaches most commonly use methodological materials on the Czech Handball Federation website (91 %), foreign union sites (49%), E -learning courses (7%) and paid internet sources (5%). The use of different sources is shown in the Table 2.

Table 2: *The use of different sources (indicated in percentage)*

	Yes	No
Methodical materials on the the Czech Handball Federation website	91	5
Methodical materials on foreign union handball websites	49	36
Methodical materials on EHF website	33	44
Methodical materials on IHF website	21	46
Video conference or webinar	12	55
E - learning courses	7	58
Online paid sources	5	58

Coaches say that they also work with foreign sources, the most used is English (41% of respondents use CD and DVD in the English language and 42% respondents use internet materials), followed by Slovak, and German. The use of foreign sources is shown in Table 3.

Table 3: *The use of foreign sources (indicated in percentage)*

	English	Slovak	German	Polish	Hungarian	Spanish	French	Russian	Norwegian
CD and DVD	41	28	39	9	2	0	5	0	0
Internet sources	42	40	24	14	2	0	0	0	2

The offer of methodological CDs and DVDs in the Czech language are evaluated in a positive way by 59% of the respondents, by 32 % in a negative way, 9% of the respondents failed to express their opinion. The same, but in foreign languages positive value of 60%, 5% and negatively failed to give 35%. However, in both cases prevails a positive evaluation.

In common coaching practice, the most widely used means of ICT is a computer – rating as overall situation and rating as each observed activity separately. There is a detailed overview of the data in the Table 4. 70% of coaches use a computer when preparing for the training unit, 51% when evaluating a match, 47% in preparation for a match, 38% when evaluating a training unit. Tablets and mobile phones are used negligibly.

Table 4: *The use of ICT in the work of coaches (indicated in percentage)*

	Computer	Tablet	Mobile Phone
In preparation for a training unit	70	5	7
During a training unit	9	0	16
When evaluating a training unit	38	2	2
In preparation for a match	47	0	9
During a match	14	0	2
When evaluating a match	51	2	7

In other parts of coaching (taking notes during a training unit, a match, communication via sound transmission equipment with another person in the stands), no significant use of ICT was registered, with the exception of evaluating a match (ICT is used with 56% of the respondents, the most used is a spreadsheet that is used with 48% of all) and a training diary guidance (it is guided with 47% in an electronic form, the most used is a spreadsheet that use 42% of the total number). There is a part of coaches who actively discuss via the internet. About two-thirds of coaches (66%) use the internet at least occasionally to discuss about their team matches with public, about their training units with other coaches and their conception of trainings (42%), 40% of coaches discuss with their players and 35% discuss about their team training units and matches with other coaches. Social networks are not widely used, only 58% of the respondents use some of them, the most common is Facebook (48%), Google+ as a second one with 14%.

There exists a difference between men and women in satisfaction with available sources, which was commented just in connection with methodological materials on CD and DVD. Women better evaluate the offer on the scale of 1-4, where 1 is the best rating for Czech and foreign language sources (1.47 in Czech language, 1.05 in foreign languages), compared to men (2.53 in Czech, 1.90 in other languages).

A significant difference between men and women exists when discussing issues related to coaching over the internet, which is largely used by women more than by men. There is a diameter calculated from the average respondents' answers in the Table 5, where the value 1 was assigned to a reply regularly, the value 2 for the response – occassionaly and the value 3 – never. Women state a significantly lower value in each of the monitored data, which means the more frequent discussions on the issues over the internet.

Table 5: *The use of ICT to discuss selected coaching issues*

	Men	Women
Discussion about the conception of their training units with other coaches	2,5	2,07
Discussion with public on sports training	2,19	1,77
Discussions about their team matches with other coaches	2,67	1,93
Discussion with public about the matches played by their team	2,87	1,8
Discussion with players on the conception of training or thein own game	2,61	1,67

Discussion

The results of the survey showed the selected characteristics of the use of ICT in non-formal education and informal learning of handball coaches in the Czech Republic. To the most frequently used sources belong materials of the union/federation websites, to the least used belong the paid sources, E-learning, webinars and video conferencing. This certainly corresponds to the offer, which is wide on the club/federation websites, on the contrary there is a minimum amount of paid sources and webinars or video conferencing, these are still not too much offered form of education. The three selected coaches who were interviewed, vary in the use of sources, but all emphasize the significant influence of other coaches (especially club colleagues and national teams coaches) on their professional development.

70% of respondents use a computer in preparation for a training unit. Preparing for the training unit was widely discussed in interviews with three selected coaches and all of them do a written preparation for a training unit and usually use a variety of materials, including methodological CDs and DVDs or internet sources. It can be assumed that most of the 70% above – mentioned coaches will act likewise. The use of computers directly during the game (stated by 14% of respondents) belongs to the interesting data. None of the three selected coaches mentions the use of computers directly in a match.

The use of tablets, which are easier to handle and could also be used in training units, is not widespread yet. Dušan Poloz states this for example when he spoke about the coach in Norway, who showed a training exercise on a tablet to his players during a training unit, just before its own implementation. He also states other examples of the sophistication in the use of ICT in Norway (eg. training diary guidance by broader national selected players in intranet, services for video editing of a match, an extensive range of methodological materials, etc.). It can also be expected a progressive use of mobile phones with a large computing power and plenty of features to use such as a camera, the ability to work with video but apparently there is a lack of appropriate applications to enable their wider use.

The data shows considerable openness of many coaches, when they are willing to discuss on the issues of their coaching jobs with others. Interestingly, very few of them discuss with their own players. Dušan Poloz justifies in this interview that any deeper discussion on these topics should be necessarily done through an oral interview.

Conclusions

The results of the empirical survey showed the selected characteristics of the use of information technologies by sports coaches. Considering the extent of the research sample (85 respondents), the presented results can not be generalized to the wide coaching population.

When compared to regular communication with others (most coaches regularly discuss on the issues of sports training with public – 15% of the coaches and 66% of them discuss at least occasionally), which is a two -way communication, with one-way drawing data over the internet (just 91% of handball coaches use methodological materials on the Czech Handball Federation website), we can submit that the one-way communication outweighs the two-way communication. This is confirmed by the low use of E-Learning (7% of coaches), webinars and video conferencing (12% of coaches stated this), which also includes the two-way communication.

Significant gender differences were found in satisfaction with some of the available materials (women evaluate all observed features significantly better than men) and in the frequency of communication about coaching issues via the internet (there is a bigger number of men compared to women who discuss about all monitored areas).

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HANDBALL AND GENDER DIFFERENCES - SPECIAL FOCUS ON THE COACHING PROFESSION.
CASE IN POINT: SLOVENIA

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Summary
Article deals with the issue of how Slovene society perceives athletes from the viewpoint of gender differences with special focus on the coaching profession in handball, which is one of the most popular sports in Slovenia. We are presenting a quantitative analyse on the sum and percentage of handball coaches among the genders; and we compare data from the years 2004, 2008 and 2012.

Keywords
Gender, education, coaching

Introduction
The role of a coach includes planning and applying training, encouraging (motivation) competitive athletes, guiding and conflict solving. The coach should have a proper way of leading the athlete to success. Responsibility of a coach towards his athlete doesn't stop with the successful career but it extends to the end of athlete's career. Conflict situations in coach-athlete relationship are the leading causes for athletes ending their sport career. The coach attends as the leader of training process. According to Mayer leading the training process denotates the process in which the leader – coach on the ground of his special skills, personal characteristics and knowledge affects persons – athletes, to accomplish imposed goals (Mayer, 2003). In many cases coach is the responsible person for planning and applying training and also for organisation, conflict solving…

Coaching takes place against the backdrop of gender ideologies that actively (re)construct and may simultaneously resist stereotypical ideas of masculine and feminine roles. In addition, the myth that links biology to athletic success and coaching expertise suggests a possible explanation for the small percentage of women coaching men's sports and at the same time, it reinforces the convention that women are not qualified to coach men's collision sports. Thus, the traditional construction of sports, which values masculine qualities of power, strength, speed, aggression, competitiveness, and resilience, creates a challenging environment for women coaches. For example, women coaches may experience incongruity between the dominant male sports construction and their philosophy, values, and behaviors.

A notable exception to the absence of women coaches in the literature is a collection of writings edited by Cecile Reynaud (2005) titled, "She Can Coach." This collection helps to fill the gap in the literature by drawing on the experiences of highly successful women coaches who coach female athletes at all levels of competition. Unlike other coaching texts that are prescriptive in nature, this collection addresses the multitude of topics related to coaching that go beyond the sport-specific techniques and tactics and further illustrates the complexity of coaching.

In Slovenia, the inclusion of women in the coaching profession in the field of handball is being monitored last two decades. During all this time it is obvious that until today women dominated above all in the bottom part of the hierarchy, while men dominated at its very top.

Methods

The population from which the sample for research was taken is defined as a population of male and female coaches who were coaching handball teams in Slovenia from 1992 to 2012 and are members of the Slovene Association of Handball Coaches (ZRTS), which is active within the framework of the Slovene Association of Handball (RZS). ZRTS keeps records of the registered coaches for the current competition season. The sample of variables in the present study has also been formulated on the basis of their archives.

The subjects made a corresponding statement about their consent to the application of personal data exclusively for research purposes and in favour of the development of handball in Slovenia.

The sample includes the following variables: sex, year of birth, education level, profession, citizenship and competition rank. The data were processed by a personal computer employing Windows environment. Used was the program SPSS for Windows. The data processing proceeded, in agreement with the goals of the research, in the following steps:

- With standard procedures we calculated basic descriptive statistical indicators and thus obtained the data on the distribution of the applied variables.
- To check the differences between the sexes, we used a Chi-square-test.

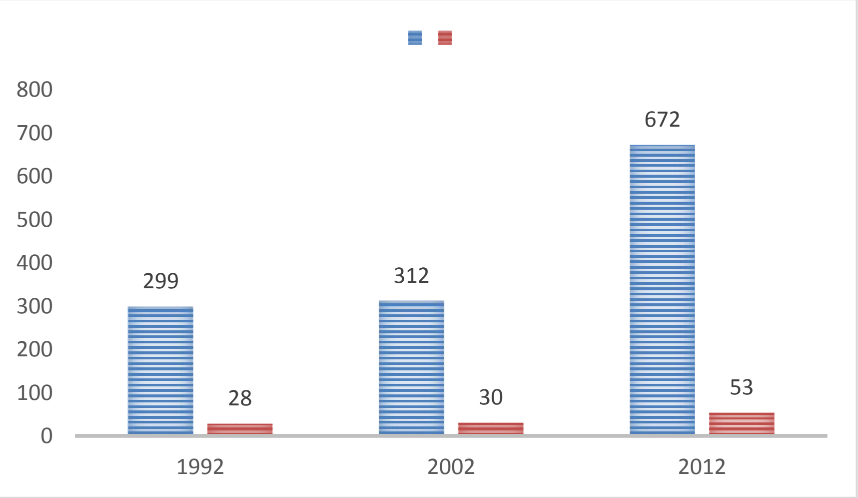
Results

From the total sample of coaches in Slovenia which was taken into account in 2012 there are 53 women out of 725 coaches, which means 7,3% of female coaches (Table 1). In the last twenty years, we can see (are following the situation) that in handball less than 10% are women coaches (Figure 1).

Table 1: *Number of all coaches in Slovene handball from 1992 to 2002*

	1992		2002		2012	
men	299	91,40%	312	91,20%	672	92,70%
women	28	8,60%	30	8,80%	53	7,30%
total	327		342		725	

Figure 1: *Percentage of coaches in Slovenia in handball from 1997 until 2002*

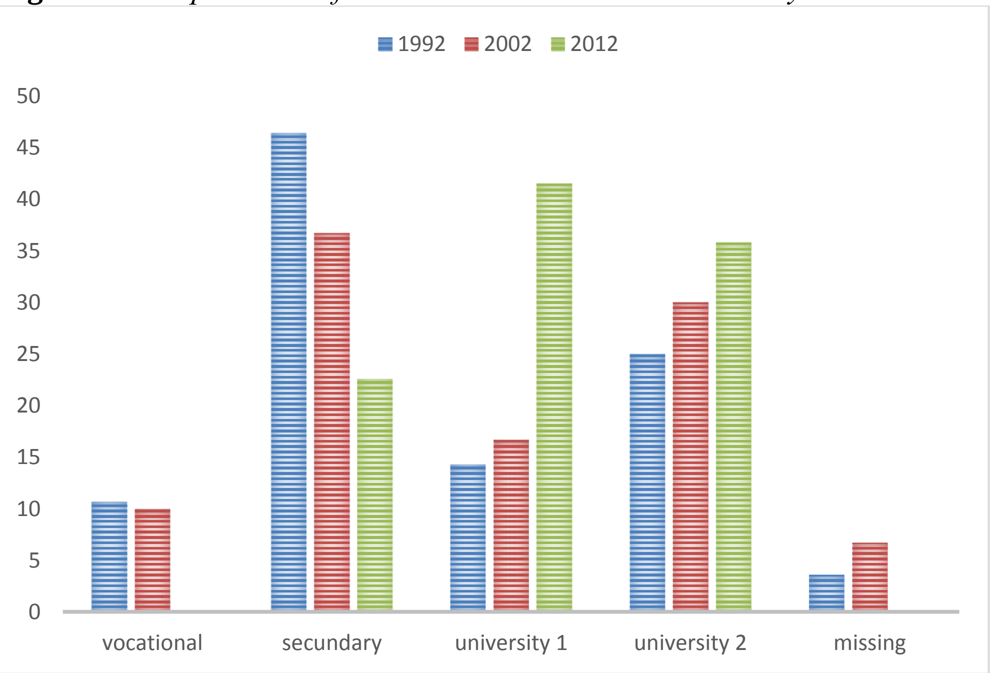


In the last year, the average age of women is on the increase (in 1992: 30 years, in 2012: 37 years); men are on average 10 years older. As in Slovenia there are many active (male) coaches aged over 50 years, we expected a larger difference in age between male and female coaches. Female coaches are from 20 – 42 years old (in 1992 between 25 to 35 years old). In the period of active playing, none of the female players includes herself in the Association of Handball Coaches (ZRTS) and becomes an active coach, while on the other hand many boys (male handball players) begin to coach already very early (at 17, 18), and include themselves into the Association of Handball Coaches (ZRTS) and in the system of competitions within the framework of the Association of Handball (RZS). These young coaches thus reduce the average age structure of coaches by almost as much as the older coaches increase it. At the same time we have many coaches who are up to 60 years old.

In contrast with the boys who are involved in coaching younger teams already during their active playing, the girls - active handball players - are more often involved in coaching extracurricular activity groups at schools on a voluntary basis. So they are not included in our sample because they are not members of coach's association. At the end of their sports career, some female players begin to coach, but they are active only a few years as they later devote themselves to their family and other roles.

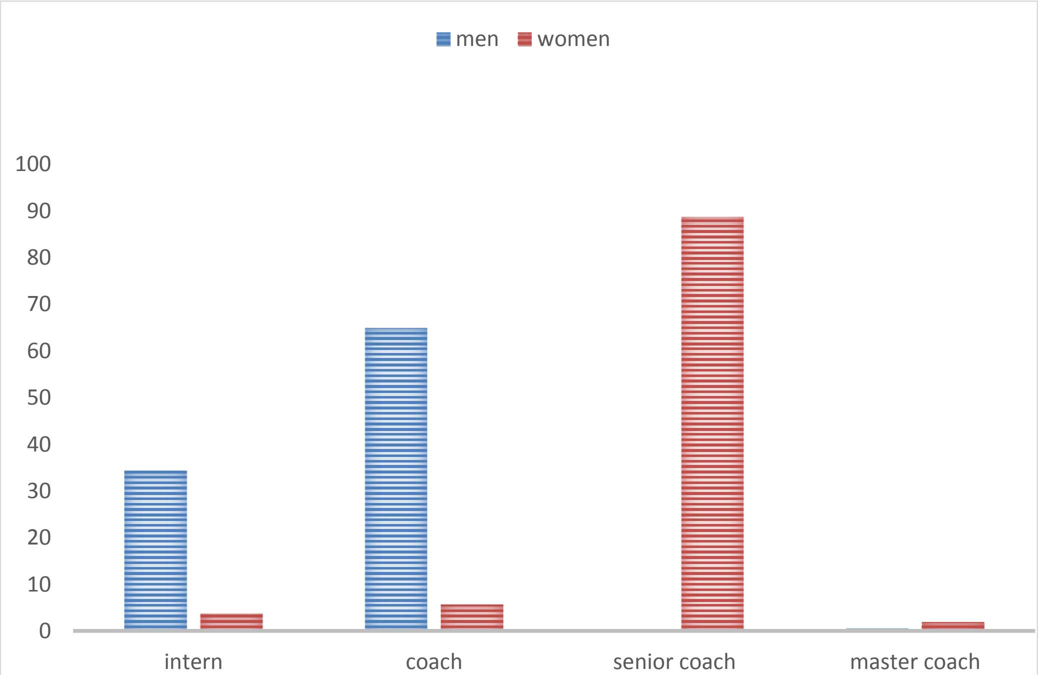
The situation regarding the place where coaches live is nearly the same during all twenty years. For example around 35% women coaches live and work in Ljubljana, the capital of Slovenia. Ljubljana, which - as a political and cultural centre of the country - allows to a certain extent that the role of women in sports is looked upon and valued from a different perspective. There is a very strong team Krim which played in semi finals of Euro-handball champion's liege 2000 and won this competition in 2001 and 2003. In Ljubljana there also live the majority of active female handball players (two top teams, one in the second division) who are involved in (semi) professional work already during their active playing. When they cease playing actively, their inclusion in the work with younger selections is also a logical continuation of their sports career. All other female coaches in smaller towns in Slovenia work more or less in an isolated manner.

Figure 2: *Comparatives of women's educational structure in year 1992 - 2002 - 2012*



Most coaches in Slovenia have the sixth degree of education (bachelor). More than 80 % (2012) of women and only 40% (2012) of men who work as coaches in handball have university education. This data is surprising as other researches indicate exactly the opposite (Doupona, 2002, Fasting and Fister, 2000). In the researches carried out so far, the relationship between men and women as regards university education is in favor of men. This indicates that in case of handball coaches we have to do with a specific pattern which confirms the thesis that women have to fight many difficulties in order to become coaches and that for success in coaching work they also need a higher degree of formal education than men. Men can be successful as coaches also if they have completed only a vocational school.

Figure 3: *Comparatives of professional educational structure in year 2012*



Most male coaches in Slovenia have second degree of coach title (coach), while most of the female coaches have senior coach title.

It is expected that in addition to the amateur title, successful coaches should also have a completed education at the Faculty of Sports as only in this way they have a sufficiently wide range of sports knowledge (physiology, psychology, sociology, theory of training, etc.). The results of our research show that only 10% of male coaches and 25% of female coaches of handball have completed the Faculty of Sports. This is data is alarming for the coaches who work with young talented children, but also for all others who take care of the development and quality of handball in Slovenia.

In view of the structural constraints put on the field of athletics and the fact that previous success – and not educational aptitude - is generally the sole criterion for the selection of coaches, there is predominant type of the coach to be found in women's sports today. That is one who ignores the educational aspirations of sport athletes and sports professionals (including coaches and lower ranking trainers), disregards the development of the athlete's personality and focuses solely on his own success as a coach. Since educational factors appear to contribute little to the enhancement of performance and the work of coaches, it is therefore not measured against educational criteria, sport education continues to be a subject for which is there is little interest (Treutlain, 2002).

Conclusion

Despite the present study of the relationship between male and female handball coaches in Slovenia, it can be concluded that that situation for women coaches is not significantly better, even if in 2003 and 2012 Slovenia was one of few countries in the world to have a woman as national coach of the women's handball national team. In view of this fact it could be concluded that the situation in Slovenia has improved. But it has not. All other facts indicate that this was merely an exception to the rule. Even though Mrs. Bon as the first and only female national coach at the level of senior women players was very successful, this did not pave the way for other women to establish themselves at the top levels. During the years under scrutiny the situation in all other areas even deteriorated. Indeed, until 2001 there was one woman in the group of Slovenia's national team national coachs, namely Mrs. Dušanka Čuk, Assistant Coach in the youth category, but presently there are no women at all. Mrs. Čuk has the highest level of education and the highest professional title of all. The second female coach, working at the highest level, i.e. in the premier handball league, has not yet been given the opportunity to establish herself at the national-team level. Even though her work at the club level has been crowned with many successes and she has adequate professional qualifications, the Expert Council which adopts decisions concerning national-team national coaches always appoints one of the male candidates and not her. What about other female coaches among whom some were former top handball players or graduated from the Faculty of Sport. Perhaps these women do not have such strong ambitions to enter the world of top sports as coaches and become public figures?

The exclusion of women from coaching (particularly from men's teams) only serves to reinforce the perception of male superiority in sports as well as coaching. The presumption that past competitive experience and the performance model of sports that values power, strength and dominating an opponent are in some way connected to coaching knowledge and expertise is widely regarded as an obstacle to women's entry into coaching (Knoppers, A.,*1994;* Treutlein, 2002; West, Green, Brackenridge, & Woodward, 2001). The decline in active women coaches (in spite of an explosion of participation in the rates of girls and women at all levels) suggests that there is a considerable loss of potential coaching knowledge. Women coaches have been effectively silenced because of their small numbers.

Once a woman enters the world of coaches, she is treated as a symbol, as a representative of a certain category, i.e. as a representative of women. This symbol reveals as a deviation from the ordinary pattern and it is necessary to fight hard in order to prevent it from becoming a stereotype (Doupona, 2002). Achievements of a woman are looked upon as a symbol of something that women are able to accomplish. A woman does not represent herself as an individual being, but she represents the category of women. On the basis of the findings of the present research we can assume that the social and sports climate in Slovenia has not yet reached that point where the abilities and successes of male and female coaches would be treated and valued equally in the coaching profession. This means that a woman must do more than her male colleagues in order to receive equal recognition...

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SPECIALISED HANDBALL CLASSES IN SLOVENIA: DIFFERENCES IN IDENTIFIED CHARACTERISTICS BETWEEN MEN AND WOMEN JUNIOR PARTICIPANTS

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Abstract

A project of handball sports classes was started at the Gymnasium with a basic purpose of creating conditions for combined development in the fields of both handball and education. One of the goals is also to offer a path to top level handball.

In this study we analysed select characteristics of young handball players (NO=56) in relation to their education and gender differences (women=32 (57.1%); men 24 (42.9%). Data were acquired with the aid of a questionnaire; the differences between the groups were analysed by means of variance analysis and a $\chi2$ test. Their learning results are particularly good (M=2,79; SD=1,0); the results of the female participants are better (M=3, 2: SD=1,0).

Many girls (59.4%) already play in a senior category, although according to their biological age they belong into the youth category. In men's categories the number is not so high (16.7%). In competition experiences we found the biggest differences between the male and women participants. Nearly all girls (59.4%) already play in a senior category, although according to their biological age they belong into the youth category. In men's category the percentage is not so high. Only 24, thus 4% of boys are playing in senior categories. These results show an early specialisation with girls could well maybe open up a topic to investigate if/why young players in Slovenia gain too much playing experience too early; as it is known many young female players stop their careers very early.

Keywords

Handball, high school, men, women, difference

Introduction

Handball sports classes at Šiška Gymnasium in Ljubljana started with a support of a Slovenian Handball Association in 2002. The basic purpose of the project for the Slovenian Handball Association was to actively participate in a complex sports and education process of talented handball players and at the same time to strengthen the handball activity in Slovenian high schools. The Slovenian Handball Association wished foremost to assist in providing participants with a possibility of well organised and expertly managed activity.

Training for participants is divided into morning and afternoon sessions. In total four morning sessions are being held at the time of school lessons, consisting of two handball trainings, track and field session and a session of acrobatics or ball games in first and second year of high school. In third year of education participants still have four trainings in the morning. Two sessions are handball training; in one session the participants work on their strength at the track and field hall; and the final session consists of training in a sports hall, which is intended for development of coordination, balance and explosive strength. When necessary or when agreed with club coaches, participants can also train in school fitness room. In the afternoons they train at their clubs, whereas for participants who are boarding, the school organises training in one of the local clubs according to their age category.

To improve general basic work, experts support many different systematically measurements (e.g. morphological status, basic motor abilities, prevention of damage, sociological status), which are organised.

The purpose of the study is to examine the motives for participants entering handball sports classes, satisfaction of participants with the work of their teachers and coaches in handball sports classes, the differences in the evaluation of coaches as well as aspirations of participants after finishing education in sports classes.

Method

Participants

The sample of participants consisted of 56 participants (80% of everyone included in handball sports classes), who in the 2007/2008 academic year attended handball sports classes at the Šiška Gymnasium in Ljubljana; average age 16.9 years (min=15.6; max=19; SD= 1,128). The sample consists of 24 boys and 32 girls. Their learning results are particularly good (M=2,79; SD=1, 0), better are girls (M=3,2; SD=1, 0).

Instrument

The sample of measured variables has been obtained with the use of standardized questionnaire for top level athletes (Doupona Topič, 2002), adapted for the handball case. The questionnaire in general contains 47 questions, which a respondent must answer using a five-grade scale (Cronbach's Alpha = 0. 85). The mean goal was to find out differences between male and female junior participants.

Procedure

The majority of questions were of a closed type. All data in questionnaire were anonymous. The questionnaire was conducted separately for each class. Instructions for completing the questionnaire were officially given by a teacher and her assistant (a student from the Faculty of sport).

Descriptive statistic parameters of variables were calculated and used for data analysis, variance analysis and $\chi2$ test were used to measure the differences.

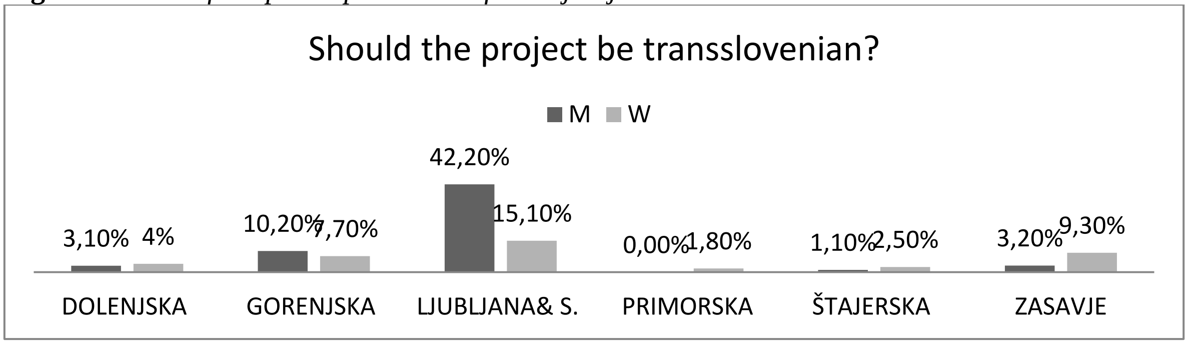
Results

Some socio-demographic characteristics

The majority of male participants (42.2%) are coming from Ljubljana and its surrounding. There is a greater dispersion among the female participants.

The majority of participants aspire to an elite sports career. Some consider it a primary focus, which occupies most of their time, whereas others set also other life priorities. Although for the latter participation in sport is an important value, they nevertheless focus on several areas in their life.

Figure 1: *Most of the participants come from Ljubljana*



The results of the study (Bon, 2010) show statistically significant differences in the motives for participation in handball between the participants in different years of study ($\chi^2 =$ 36,343; p = 0, 00). 37% of all participants desire to become elite athletes, with results for separate years of study being 47% in the first year, 38% in the fourth year and 30% in the second and third years of study.

Competition experiences of participants in handball sports classes

Handball competitions for senior men in Slovenia are being held in 1^{st} A, 1^{st} B and 2^{nd} division categories, whereas senior women play only in 1^{st} A and B divisions. Further down are the junior national leagues and youth national league.

Table 1: *Competition experience*

LEVEL	WOMEN	MEN	W%	M%	TOTAL
1.A	19	4	59.4%	16.7%	23
1.B	4	3	12.5%	12.5%	7
2^{nd}	0	4	0%	16.7%	4
YOUTH	6	9	18.8%	37.5%	15
JUNIOR	1	3	3.1%	12.5%	4
STOPPED PLAYING	2	1	6.3%	4.2%	3
TOTAL:	32	24	100%	100%	56

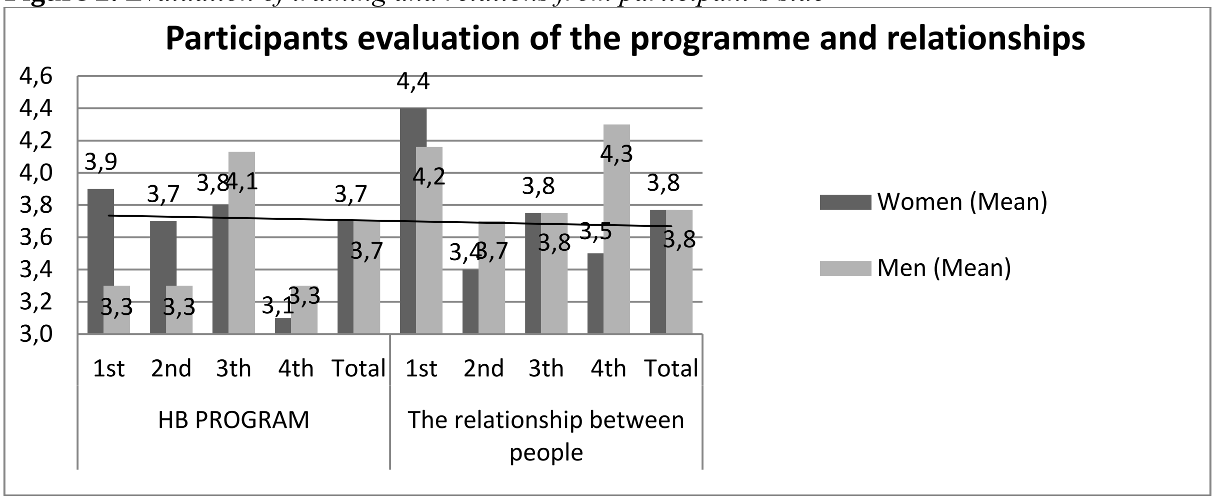
The majority of participants (n=23; 41.1%) play in the 1^{st} A league, 28% play in a youth league, 13% in a 1^{st} B league, whereas 7% play in both junior and 2^{nd} division senior league.

Results also revealed that 58% of first year participants play in senior divisions, although they could play at a youth level throughout first and second year of high school. A high percentage of participants (38%) play in the 1^{st} A league where there is no age limits and is primarily intended for seniors. Obviously, a characteristic of Slovenian handball is that players, particularly girls, often play in a team with older team mates. Results revealed statistical differences between male and female participants (χ^2=32,01; p = 0, 008; p <0,005).

The study Bon (2011) also examined whether participants view that the inclusion in the project of handball sports classes awards them a special status in a club (e.g. more important, higher playing role in the team). The results show statistically significant differences in the answers of participants in different years of study (p <0,005; p = 0,001; χ^2= 6,545).

There are, in total, only 16 members of different national teams. Highest number of national team members has been detected in the first year of study (n=8) as being the members of a birth year 1992 national team. Statistically significant differences can be noticed between the participants in different years of study (p = 0,00; χ^2= 50,572); higher the year of study, the stronger selection and more limited numbers (Bon, 2011). In the fourth year of study, there are only two members of Slovenian A national team and one in youth national team, all of them are women.

Figure 2: *Evaluation of training and relations from participant's side*



The quality of the relationship between the coach and an athlete influences the motivation of an athlete and, consequently, achievements at competitions. Therefore, a degree of mutual understanding between the participants and the coaches in school and clubs has been examined. First year participants showed the best relationship with the coaches whereas the third year participants indicate the worst relationship. Nevertheless, a total average value is 3.7 (on a scale of 1 to 5), indicating generally good relationship between the participants and coaches.

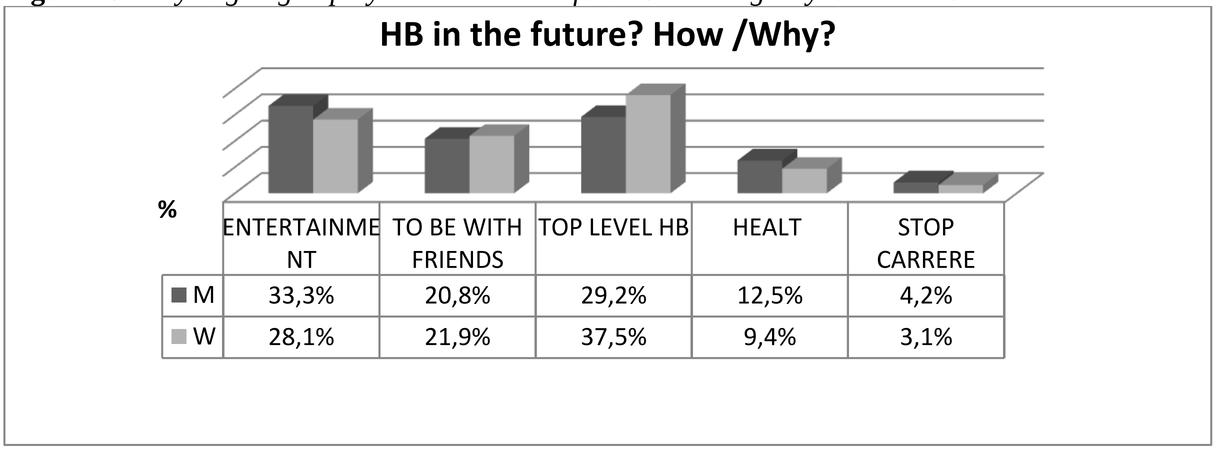
Statistically significant differences can be noticed between the participants in different years of study (M=3,77; SD=0,85; p = 0,009) an also between men and women participants (M=3,59; SD=0,82; p = 0,008). First year female participants viewed relationship with teachers and coaches as excellent (4,4), and in fourth year not so good (3,5). First year participants showed the best relationship with the coaches, whereas the third year participants experienced the worst relationship.

Results do not reveal statistically significant differences in answers of participants in different years of study (p = 0, 143; χ^2= 9,598) about the quality of work of coaches in clubs and school.

In another study (Bon, 2010) it indicated that participants are satisfied (M=4,13; SD= 0,81p=0,19) with the available conditions at the school and there are no statistically significant differences in answers of participants from different years of study (F=0,858; p = 0, 469). Satisfactions with the training conditions in Slovenia vary from one sport to another, as some of the sports are more represented than others and consequently receive more funds (Bon, 2011).

Most of female participants (n=21) consider the training in school as dynamic and diverse, whereas the percentage of fourth year participants stands at 39%. Although the difference is statistically not significant (p = 0, 581; χ^2= 1,917), presumably the differences occur due to the longer education time at the school. One reason is also that women evaluate differently.

Figure 3: *Are you going to play handball in the future? Please give your reason?*



	ENTERTAINMENT	TO BE WITH FRIENDS	TOP LEVEL HB	HEALT	STOP CARRERE
M	33,3%	20,8%	29,2%	12,5%	4,2%
W	28,1%	21,9%	37,5%	9,4%	3,1%

On the basis of the analysis of several questions it can be concluded that handball represents an important area in the life of the majority of participants in handball sports classes. The use of χ^2 test revealed no statistically significant differences in answers (p = 0, 27; χ^2= 14,36) about the purpose of education in specialised sports classes. Nevertheless, not all the goals of the participants are related to handball.

Conclusion

Education, for many years, is a part a planning sport career of young athletes (Brettschneider, Sack, 1996; Gill, 1998; Patterson, 2008; Bon, 2011). In this study we analysed select characteristics of young handball players in relation to their education and gender differences. In the first part of the study an investigation was carried out on a sample of 56 participants (women=32 (57.1%); men 24 (42.9%), attending handball classes. Data were acquired with the aid of a questionnaire; the differences between the groups were analysed by means of variance analysis and a χ^2 test.

The biggest differences are in competition experience. Nearly all girls (59.4%) already play in a senior category, although according to their biological age they belong into the youth category. In men's category the percentage is not so high. Only 24, thus 4% of boys are playing in senior categories. At the beginning of the high school education almost half of participants (both girls and boys) aspire to play professional handball at the end of high school; whereas in later years of their education, the participants - especially girls - increasingly prefer socialising and entertainment. These results show an early specialisation with girls could well maybe open up a topic to investigate if/why young players in Slovenia gain too much playing experience too early; as it is known many young female players stop their careers very early.

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ORGANIZATION OF COMPETITIONS IN YOUTH HANDBALL

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Summary
This article presents the results of a survey of 276 Portuguese handball coaches about the goals for the competition of young people up to 15 years, priority should guide the preparation for the competition of these young people, about the ideal age to start participating in regular competitions, the importance of the roles that can perform the competition and the importance of the inclusion of these topics in their training.

Introduction
This research, carried out using the auscultation of Portuguese handball coaches aimed to find out what the opinions of these coaches on the objectives and perspectives for training and competition for children and youth handball. The relevance of this study is based on the fact that even today there is a great discussion on this topic, and however few studies in order to know the opinion of the coaches, recognized by all as essential elements of this process. In our original study tried to find out, through a questionnaire, the opinion of the Portugal handball coaches on the participation of children and youth in organized sports, having removed to this article as follows: 1) Distinction between the competition goals youth and adults, particularly on the priority of the goals set for the competition (training versus outcome) and training objectives (preparation multilateral versus specialized) in different age groups, 2) Functions of the competition during sports training in handball; 3) about the values and attitudes that can be developed in children and young people during the competitive participation in the formative years, 4) on the ideal level of initiation to participate in regular competitions in handball; 5) on the importance to be attached to the related topic role of competition and the shape of his organization, in the training courses for coaches.

Material and methods
For the study we used the questionnaire Cardoso (2007), appropriately adapted and validated, it was applied to handball coaches during the action of mandatory recycling that took place early in the season, the national and regional level. The data was digitized using the program Microsoft Excel, then imported and analyzed with SPSS 18.

Sample
The sample (significant in the world of handball coaches) consisted of a total of 276 coaches attending the national recycling (2 no degree, 24 grade 1, 51 grade 2 and 154 grade 3) whose questionnaires were considered valid following their consideration.

Procedures
We applied the questionnaire, scanned the results and made up a descriptive analysis of the data normality (Shapiro-Wilk test) and homogeneity (Levene test). It also appealed to the statistical Kruskal Wallis test, with a significance level of 0.05, verifying that there were significant differences of opinion between groups of trainers with different training backgrounds.

Presentation and discussion of results

Opinion of the coaches on the priority in terms of objectives should guide the competition of Under 8, Under 10, Under 12, Under 14 and Youth.

The opinion of the coaches about how this research should evolve the objectives of the competition by several steps, as follows (Table 1): 1) for the Under 8, 86,8% consider that the competition must have exclusively formative objectives, 2) for the Under 10, 77,5% continues to think that the objectives to be achieved in the competition must be solely training; 3) for the Under 12 most think that the participation in the competition should give greater emphasis to the goals of character training (28% and 52,9% only formative emphasis on formative); 4) for the Under 14, 56% believes that greater emphasis should keep the training objectives which results in the competition, but 44,0% leaning towards granting greater emphasis on competitive results; 5) finally, for ranking Youth (15, 17 years of age for male and 15, 16 female): most coaches emphasizes competition results (30,2% more emphasis to the results, 44,6% emphasis on results in competitions).

Table 1: *Choice of Portuguese coaches on the priority goals for the competition at youth level*

Priorities	Only training	More emphasis on training	More emphasis on results in competitions	Emphasis on results in competitions	Total
Under 8	86,8%	8,3%	3,1%	1,8%	100%
Under 10	77,5%	17,6%	3,1%	1,8%	100%
Under 12	28,8%	52,9%	10,7%	8,4%	100%
Under 14	8,5%	47,5%	21,1%	22,9%	100%
Youth	4,5%	20,7%	30,2%	44,6%	100%

Tested the database revealed the existence of statistically significant differences (at the 0.05 level) between the opinions of coaches, depending on the technical grade, with regard to priorities for the age of children: (nonparametric ANOVA Kruskal Wallis p = .032). With the other bands there were no statistically significant differences (Kruskal Wallis tests and Mann-Whitney test, with p>, 050).

Most coaches argue that for the younger age groups (Under 8, Under 10, Under 12 and Under 14) the competition must have priority training objectives, level of Youth have to emphasize the goal of achieving results in the competition, in the first case the results are according to the advocated by much of the literature on the subject such as Balyi et. al. (2010), Adelino, Vieira and Coelho (2006) Throat (2006), Malina & Cumming (2003), Baker (2003), Côté, & Lidor Hackfort (2009) and Hedstrom & Gould (2004), in accordance with the responses coaches denote a tendency to concentrate the stress competitive results in a phase in which, according to the references, this should not yet be the most important goal for competition, because it can lead to specialization early in the preparation, via the influence of goals in the competition over training.

Priority should guide the preparation for the competition in handball, according to the training objectives, in the opinion of the Portuguese handball coaches.

As the priority that should guide the preparation for the competition in handball for children and young people most technicians have the following opinion (see table 2) that in the step of the preparation should be Under 8 primarily multilateral (88,1%) and that the level of minis preparation should be multilateral (72,90%), whereas the level of Under 12 preparation has already characteristic of expertise (42,1% and 28.7% specialized to most specialized multilateral), that in step started the preparation must have characteristics of specialization (42,10% and 29,20% only specialized to most specialized multilateral) and the level of Youth preparing to be specialized (69,20%).

Table 2: *Priority should guide the preparation for the competition in handball in accordance with the training objectives*

Priorities	Only multilateral preparation	More multilateral than specialized	More specialized than multilateral	Only specialized	Totals
Under 8	88,1%	5,4%	1,5%	5,0%	100%
Under 10	72,9%	17,7%	3,9%	5,4%	100%
Under 12	3,1%	26,2%	28,7%	42,1%	100%
Under 14	2,6%	26,2%	29,2%	42,1%	100%
Youth	0,5%	11,8%	18,5%	69,2%	100%

Given the statistical analysis of the data reveals the existence of statistically significant (at a significance level of 0.05) between the opinions of coaches due to technical grade, the results in the step of duiker (nonparametric ANOVA Kruskal Wallis p =.005) and step Under 10 (Kruskal Wallis p = .045).

In a contradictory opposition hit the view expressed in the previous question, the coaches of this research advocate a style of specialized preparation, right from the level of children, which shows a trend towards early specialization in the preparation of young handball players already at the 11, 12, face a very early age literature (Balyi et. al. 2010; Adelino, Vieira and Coelho, 2006; Throat, 2006; Malina & Cumming, 2003; Baker, 2003; Côté, Lidor & Hackfort, 2009; Baker, 2003; Bailey, et. al., 2010; Malina, 2003; Hedstrom & Gould, 2004) refers to this early specialization as one of the problems of youth sports possible enhancer of burnout and dropout. Thus, the Portuguese handball youth may be facing a problem limiting its development that need to be resolved.

Degree of importance attributed by the coaches to the functions they can perform the competition among the young.

- Provide opportunities to compare their abilities with those of others and themselves.
  This function is considered as very important for 7,4% of the coaches, important by 37,4%, somewhat important by 28,1%, very unimportant by 13,7% and 13,3% for anything important.
- Creating together with friends, peers, third party a good social image.
  Enable children and young people to create with friends, peers, third party a good social image, is regarded as very important (13,7%), important for 41,5%, somewhat important (29,3%), very little important (10,0%) and not important (5,6%).
- Enabling the child or young person to succeed and to overcome and build their self-image and self-esteem.
  A considerable majority of the technicians assigned significant importance (56,7% very important and 38% important) to this function, while only about 4,5% than the value (3,7% minor, 0,4% very unimportant and 0,4% not important).
- Contribute to help children and young people acquire and develop values for their future life in society
  This factor is considered as very important for 73,0% of the Portuguese handball coaches, important for 24,0%, somewhat important (1,1%), very unimportant (1,1%) and not important (0,7%).
- Enabling children and young people of being with friends and make new friends.
  This function is considered as very important for 47,8% of the coaches surveyed, important for 45,9%, to 5,2% unimportant and very unimportant to 1,1%.
- Motivating young people to achieve their goals.

This possibility allowed by competition, is seen as very important by 71,4% of technicians surveyed, 26,4% for important, unimportant and very unimportant by 1,1%. With the statistical analysis we conclude that there are no statistically significant differences (for a significance level of 0,05) between the opinions of coaches due to the technical grade.

Most coaches questioned attaches significant importance to all functions presented here, leading us to believe that they are concerned with important training components that can be exploited during the competition, as recommended in the literature (Malina and Cumming, 2003; Hedstrom and Gould, 2004; Bailey et. al., 2010 Balyi et. al., 2010). These study results demonstrate that the coaches have concern for psychological factors (motivation) and psychosocial (developing positive self-esteem and self-concept), social factors (creation of social capital, create friends and socialize with peers) and behavioral factors (creating values through sports competition), important fact if we refer to the literature on the benefits of sport participation.

Degree of importance attributed by the coaches to the values and attitudes that can be developed by children and young people through sports participation during all stages of training.

Most coaches respondents consider as very important the development of the following values and attitudes: be fair and honest (61,7%), being a companion to be with friends (52 %), being a conscientious give up and do better (72,5%); strive to be persistent and persevering in the game and competition (64,6%); take pleasure, having fun (75,2%); having personal achievement, do the best you can (50,2%), have self-fulfillment, feeling good when you play (50,7%), showing sportsmanship , having appropriate behavior, do not be a sore loser (64,6%), being a cohesive, stimulate and encourage the team when things are difficult (62,4%). Important: compassion worry about people around (62,4%); demonstrate compliance integrated into the group (51%); playing well (54,8%); become more fit and healthy through sport (51,6%), to be obedient, do what you ask (62,3%); displaying competence and skill, as well performing skills and techniques (61,4 %) and to be tolerant, to engage with others even not liking them (59,7%).

None of the groups analyzed the statistical tests verified the existence of statistically significant differences (Kruskal Wallis and Mann-Whitney test with p> ,050) between the opinions of experts in terms of its technical grade.

These results demonstrate a significant concern of the coaches interviewed for values and attitudes that can be developed during the competitive participation, such as justice and honesty; development of acquaintance and friendship, resilience and self-realization, acquisition and development of values for future life in society, become more fit and healthy through sport; compassion and solidarity. We are pleased to also check that technicians also attached great importance to the pleasure and enjoyment of children and youth during sports, components considered in much of the literature as key reasons for the retention of young people in sport (Malina & Cumming, 2003; Fraser- Thomas, Côté and Deakin 2005; Bailyi et al. 2,010; Dieffenbach & Gould, 2003).

Echelon considered by coaches as the ideal to start participating in competitions of competitive frameworks regular handball.

A significant percentage of the coaches (43,6%) of this sample considers the level of Under 12 as the ideal for children and young people started participating in competitions of competitive frameworks regular handball, and 29,9% such participation should take place as early as the ranking of Under 10. Few coaches that refer to this fact later to echelon started and 12,3% for 1,9% of Youth.

Regarding the statistical analysis, it appears that there are no statistically significant differences (for sig. 0.05) between the opinions of total national technicians, according to the technical grade (ANOVA nonparametric Kruskal-Wallis p = .423). This result reflects the membership of the coaches to the tendency of most Portuguese youth sports organizations to adopt new competition from younger who follow a logic similar to the competitive structure of the seniors with very slight adjustments (Adelino, Vieira and Coelho, 2006) a trend which usually leads to an early specialization of practice under the influence of competition style adopted.

How important is the inclusion of issues related to the role of competition in the training process, the courses and training activities for trainers?
A significant majority of the coaches (54,4% important, 31% very important) this study considers to be desirable to include courses in coaches or periodic training of topics on the role of competition in the training process, the inclusion of items on the organization of the competition also desired by most surveyed (51% think it important and 21,4% very important) and 87% attach significant importance (41,7% very important or important to 48,3%) the inclusion of items on the preparation for participation in the competition.

In this chapter the statistical tests show no statistically significant differences (for sig. 0.05) between the opinions of technicians, according to the technical grade, the responses of these issues. It is clear that the coach's respondents consider important to include the topics presented here in their courses or training activities regularly. Possibly this is a sign that these technicians feel relatively insecure in relation to these issues and would like to discuss these issues and deeper.

Conclusion
Most coaches argue that for the younger age groups the competition should primarily emphasize the training objectives and competitive goals in the Youth level. The technicians surveyed also tend to support a style of specialized preparation, right from the level of Under 12.

A significant majority of the coaches participating in this study attaches significant importance to all functions of the competition presented here, demonstrates significant concern for the values and attitudes that can be developed using the participation in competitions (justice, friendship, companionship, honesty, resilience, solidarity ideal age for onset of youth participation in regular competitions; argue that participation in regular competitions to take place from 10/12 years of age and considers the inclusion of issues related to the role of competition in the training process in their courses or actions and regular training.

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HANDBALL TEACHING AT SCHOOL: A PRE-SERVICE TEACHING EXPERIENCE AT THE PRIMARY SCHOOL

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Summary
The goal of this study was to evaluate the effectiveness of using a tactical and comprehensive approach to teach handball at school. The study was a research-action project concerning the usage of modified game forms: 4X4, 4^{+}X4 and 5X5. Seventeen students (10 male and 7 female) from 4th grade (9-10 years old) were involved, in the scholar year of 2012-13. The results reinforce the importance of using simplified game forms to teach handball at school.

Keywords
Handball, basic game form, teaching

Introduction
In the last few decades, several authors have pointed out the need for a tactical approach to teaching and learning invasion team sports (Michell, 1996). This approach emphasizes the need for authentic learning experiences (Siedentop et al, 1994), more comprehensive knowledge of the game (Bunker and Thorpe, 1982) and a *tactical* decision based learning model (Gréhaigne et al, 2005). In the opposite side there is a more traditional approach based in a synthetic learning of *technical* skills.

We must realize that the *technical*, the *tactical* and the *conditional* realms are interdependent. Ideally, the game is planned at a tactical level and the tactical options (the game model) are what is going to drive the technical choices. Then, both the tactical and the technical options require a certain degree of *physical capability*. But in reality, technical and tactical options frequently have to be adapted to the number of players, opposing team strengths, physical capacity and technical skills available, etc.

In this pyramid of competences (conditional, technical, tactical), it is usual to start teaching from the first (conditional) to the last (tactical). We defend the other way round. The tactical reasoning is the skill most difficult to teach/learn, the one that requires more time to master and usually the main difference between a great and a not so great player. So we advocate the need to let the tactical teaching drive all the training/learning process. Also, what is not irrelevant, this methodology seems much more stimulating and enthusiastic for students.

This way, the initial concern for those wishing to teach handball is to understand the handball game, the fundamental tactical problems and associated techniques. This is the basis that will allow the teacher to adequate the game complexity and learning tasks to the students' level. Commonly the initial game form is the 5X5 (mini-handball), but based on our experience and as suggested by Estriga and Moreira (2013) at the primary school simpler game forms should be adopted. The purpose of this study was to evaluate the impact in the learning process of different game forms, namely the 4X4 with and without advanced goalkeeper and the 5X5.

Methods

Context

This experience occurred during the Practicum (Master degree in Sports for Children and Youth), in the school year 2012-13.

Participants

Seventeen students (10 male and 7 female) from 4th grade (9-10 years old) were involved, in the scholar year of 2012-13.

Description

This experiment comprised 8 teaching sessions of 90 min each for a 4th grade class, all of which were videotaped respecting the ethical canons in place (authorizations, anonymity, etc). A pre-service teacher was in charge of the class.

For evaluating the learning progression of the essential skills and global game performance, a specific observation form was developed based on the Game Performance Assessment Instrument (Oslin et al. 1998).

Data Collection and Analysis

A specific instrument was developed to collect the data:

- A motor test was constructed based on the *Game Performance Assessment Instrument* (GPAI) (Oslin et al., 1998) for evaluating essential skills and game play performance. The classification of technical and tactical behaviors was adapted from Ferreira et al. (2011), being grouped in the following categories: skill execution, decision making in attack and decision making in defense. The individual performance was classified as appropriate/efficient or inappropriate/inefficient for each game situation observed. The behaviors and adequacy data were re-coded in the following variables/indexes: *game involvement* - total sum of appropriated responses; *skill execution index* – ratio of efficient skill executions by number of actions*; throwing opportunities* – number of appropriated throwing opportunities*; throwing efficiency* – ratio of scored goals by the number of shots at goal.

Teaching Unit

In the first lesson the majority of the students were introduced to the handball for the first time. After a brief rules and game spirit explanation students were evaluated during a 4X4 match in a reduced field (smaller than a mini-handball court, with a goal area of 4 meters). After this session it was decided to split the class into three homogeneous teams. Each team nominated a player-coach, chose a team name and were encouraged to organized themselves as a team.

The initial evaluation was used to observe the game play competence and to decide the learning objectives. The competence differences among students where already very noticeable despite their young age. In general girls showed a lower ability level than boys. Considering the students' tactical understanding and level of skills the first basic game form of handball was adopted, as recommended by Estriga and Moreira (2013).

There were a total of 8 lessons of 90 min each for the handball teaching unit, so we decided to implement a hybrid teaching model approach adapting some concepts from the Sport Educational Model (Siedentop, 1987). Therefore specific competitions (class league and cup) were organized during the teaching unit. For this reason, it was necessary to build materials to support the students' activities and competitions.

Table 1. *First Basic Game Form: tactical problems in the attack (adapted from Estriga and Moreira, 2013)*

TACTICAL PROBLEMS			**ATTACK**
	SCORING	**Off-the-ball actions**	**On-the-ball skills**
	Maintain possession of the ball	Create passing lines Move to catch the ball	Control/handle the ball Pass to teammates without defenders
	To progress (forward the ball)	Move ahead to an open space ball-owner orientated Continue moving after releasing the ball	Receive the ball while moving Dribble to the goal without an advanced/open passing line Pass the ball ahead of the receiver
	Attack the goal	Move and adjust position to receive and throw	Advance to goal whenever in a favourable situation(exploring steps cycle and dribbling) Shoot without opposition and in front of the goal
			DEFENCE
	PREVENTING SCORING	**Actions and skills**	
	Defend the goal and win the ball	Move to catch the ball Interception Positioning between the ball-owner and the goal-area	

The warming up (mainly small funny games, with throwing, dribbling, catching, etc.) was performed by all students collectively after which they split in three groups. The lesson space was divided in three different fields where the teams performed different tasks: coordinative exercises with throws, partial game forms (2X1 and 3X2) and basic game forms (4^{+}X4 and 4X4). If there is a competition, two teams were playing while the third one was performing a specific learning task decided by the teacher and managed/implemented by the coach-player. In table 2 a brief description of the playing situations that were used for analysis is presented.

Table 2. *Organization of the teaching unit*

Lesson	Filmed paying situations	Tasks and organization
1	4X4, only boys 4X4, only girls	Diagnostic evaluation
2	Groups organized by teams (with both sexes) 4^{+}X4, mandatory advanced goalkeeper.	Preparation for the competition: learning and training as a team
3	Groups organized by teams (with both sexes) 3^{+}X3, mandatory advanced goalkeeper.	Preparation for the competition: learning and training as a team
4	Groups organized by teams (with both sexes) 4^{+}X4, mandatory advanced goalkeeper.	Preparation for the competition: learning and training as a team
5	Groups organized by teams (with both sexes) 4^{+}X4, mandatory advanced goalkeeper. 4X4, no mandatory advanced goalkeeper	Competition between teams - *League*
6	Groups organized by teams (with both sexes) 4X4, no mandatory advanced goalkeeper.	Competition between teams - *League*
7	Groups organized by teams (with both sexes) 5X5, no mandatory advanced goalkeeper	Competition between teams - *League*
8	4X4, boys 4X4, girls	Final evaluation *Ermida* Cup – culminating event

Results and discussion

From this experiment we have extracted a wealth of information. Here we want to report three simple but important results: 1) in general the students improved the measured behaviours after being submitted to this program; 2) at this school level the most simplified game forms are more effective than the more complex game forms; 3) and the girls have more playing opportunities when playing alone when compared with mixed groups (both girls and boys).

The observed results between the diagnosis lesson and the final lesson reveal that girls improved their performance in almost every item when playing alone (see figure 1). The increased throwing opportunities and increased efficiency are important key points for motivation and engagement, so these results are very encouraging for teaching handball at school.

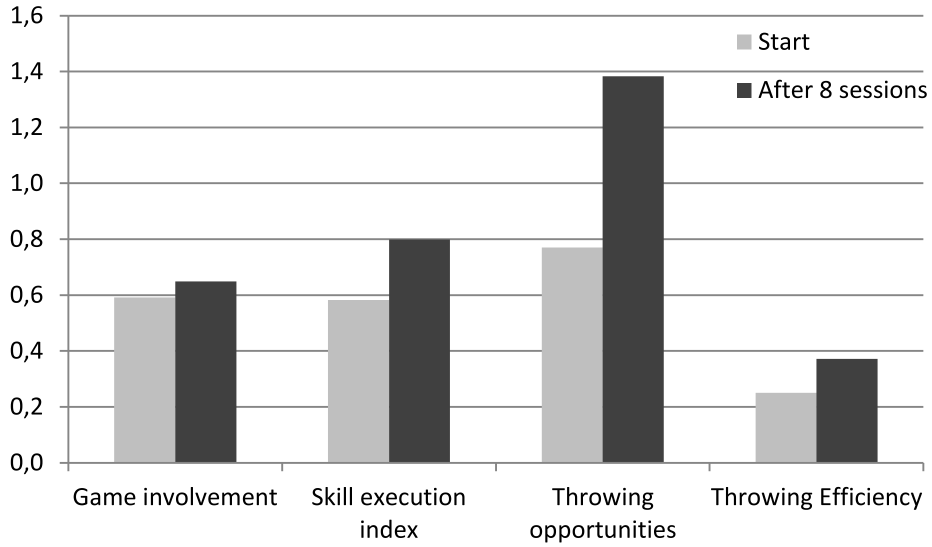

Figure 1. *Game performance evolution of girls – comparison between the first and the last evaluation, in similar playing conditions.*

When comparing the 4X4 and 5X5 modified game forms the results confirmed our beliefs and empirical knowledge: the simplest playing form is preferable. The slightly more complex form 4^{+}X4 (4X4 with mandatory advanced goalkeeper) is introduced early because of its value in teaching numeric superiority. The conclusion is that the more rich game forms (5X5, 6X6 and 7X7) should be introduced only at later stages, when the simpler forms have exhausted their teaching value.

Figure 2. *Comparison between different modified game forms: 4X4 with and without a mandatory advanced goalkeeper and simple 5X5 (mini-handball).*

Another interesting result was that, at this age, boys frequently have much higher skill level than girls and tend to exclude girls if mixed teams are used. This male protagonist is mostly obvious in terms of scoring opportunities (figure 3).

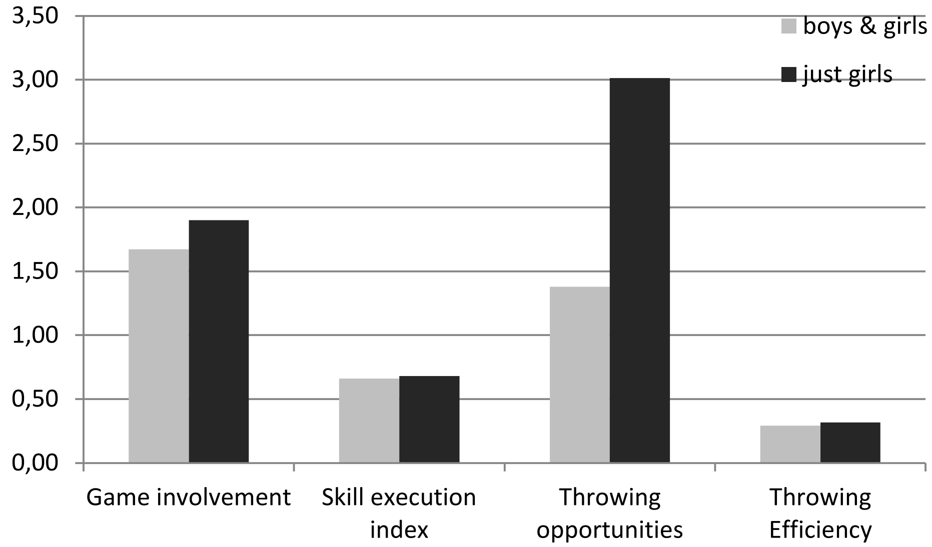

Figure 3. *Comparison of game performance of girls when playing alone and when playing in mixed teams.*

Conclusions

The results revealed a significant increase in students' handball competence, both from an individual and collective perspective. The 4^{+}X4 game form (with a mandatory advanced goalkeeper) showed a major impact in students' playing opportunities and game inclusion. In general, the students showed great enthusiast and motivation to play handball and improved greatly their game skills in handball.

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PSYCHOLOGICAL CHARACTERISTICS OF THE TOP PORTUGUESE HANDBALL PLAYERS: COHESION AND PERSONALITY

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Summary
The purpose of this study was to examine the relation between task cohesion (ATG-T, and GI-T) and the big 5 personality factors (NEOPIR). Participants are 102 top handball athletes, aged between 16 to 35 years old, from Portugal's selection level. Our results show that female athletes report experiencing higher levels of task and social attraction to group than male athletes. Only Agreeableness relates in a significantly way with the perception of task cohesion (ATG-T) in both female and male gender.

Keywords
Group Dynamics, cohesion, personality, Handball

Introduction
Team cohesion is a proxy to team functioning and defined as "the resultant of all the forces acting on the members to remain in the team" (Festinger, 1950). Sport psychologists have also contributed for this, and the work of Carron et al is well known and recognized at international level. Carron (1982) defines group cohesion as "the tendency for a group to stick together and remain united in the pursuit of its instrumental objectives and/or for the satisfaction of member affective needs" (p. 214), as a multidimensional construct comprised of both task and social aspects, and involving the dual processes of integration into the group and attraction toward other group members (Carron et al., 1985; Carron et al., 1998). Therefore team cohesion breaks down into interpersonal or social cohesion and task cohesion. Social cohesion concerns an individual's attraction to the group because of positive relationships with other members of the group. Task cohesion refers to an individual's attraction to the group because of shared commitment to the group task (Brawley, Carron & Widmeyer,1987; Zaccaro,1991). Thus, four dimensions come into sight: Individual Attractions to the Group-Social (ATG-S), Individual Attractions to the Group-Task (ATG-T), Group Integration-Social (GI-S) and Group Integration-Task (GI-T).

In a reflexive analysis of the work developed by Carron et al. (1985), Cota, et al. (1995, p. 566), outlined the multidimensional model by two fundamental reasons: "First, both of the presented dimensions are very important to understanding cohesion in different types of group, having been identified by other authors in an independent form. Second, the implications of both subscales were tested in a growing number of works". Also Blanchard, et al. (2000) suggests the relevance of the GEQ as the most chosen instrument among sport psychologists to access group cohesion.

Based upon earlier work many personality researchers argue that the universe of trait dimensions can be reduced to five bipolar categories (McCrae, 1992; McCrae & Costa, 1987). The five-factor model, as conceptualized by the NEO-PI, consists of neuroticism (e.g., anxious, sadness, impulsiveness), extraversion (e.g., assertive, active, talkative), openness (e.g., active imagination, aesthetic sensitivity), conscientiousness (e.g., purposeful, strongwilled, determined), and agreeableness (e.g., altruistic, sympathetic; Costa & McCrae, 1992). Each of the five factors have been viewed as an adaptive set of traits that assist both the individual and group in meeting their survival needs. The NEO-PI is a measure of normal personality that has been successfully used with clinical and nonclinical populations (Costa & McCrae, 1992).

A meta-analysis by Mullen and Copper (1994) showed that task cohesion has a stronger relationship with group performance than social cohesion. Unfortunately, however, Barrick et al. (1998) focused on social cohesion only and ignored its (potential) relationship with one of the Big Five dimensions: openness to experience. Their results regarding social cohesion showed no relationships with composition measures of conscientiousness, positive relationships with all composition measures of agreeableness and extraversion, and positive relationships with the mean and minimum level of emotional stability. In the current study we expected to analyses the relationship between social and task cohesion and each of the personality dimensions:

Extraversion - Communication about how the tasks have to be done is important for making the team's strategies and goals more explicit, i.e. for getting people facing the same direction. Extraverts are more likely to initiate discussions, to be active and energetic and to be perceived as leaders). They therefore could enhance task cohesion. Barry and Stewart (1997), however, revealed that a higher proportion of extraverts was not associated with openness of within-group communication and reduced the task focus of the group. They suggested that "extraversion increases the quantity of verbal communication but without necessarily affecting its quality" (p.75). Thus, whether or not extraversion positively affects task cohesion very much depends on the content of the communication and the nature of the tasks to be done. We therefore expected no relationships between measures of extraversion and task cohesion.

Emotional stability/ Neuroticism - Emotionally stable individuals are self-confident and secure about the goals that have to be chosen and the decisions that have to be made. Moreover, individuals low in emotional stability will repeatedly call decisions into question, because they are anxious about taking decisions and they feel uncertain about their own and others' ideas. Hence, work teams with higher mean levels of emotional stability will report greater task cohesion.

Openness to experience - This personality factor is represented by traits such as "decides things on his/her own", "takes charge", "takes risks", "engages in discussions" on the positive pole, versus "follows the crowd", "waits for others to lead the way", and "does what others want him/her to do". If a work team consists of individuals that are all high on autonomy this may lead to many discussions and fights for getting control and power, which will be damaging for both social and task cohesion. On the other hand, when only one team member rates high on autonomy and others are the followers (low on autonomy) this may create task cohesion in the group, so we expect a positive relationship.

Conscientiousness - Individuals high in conscientiousness share the need for being organized and to achieve individual and team goals. Individuals low in conscientiousness share the tendency to be disorganized and approach the task in a less structured way. When a team consists of both high and low conscientious members, there may be substantial disagreement and irritation about how to approach the task, and what to achieve. Put otherwise, we expected homogeneity in conscientiousness to affect task cohesion: The more similar team members are in terms of conscientiousness, the higher the team's task cohesion will be.

Agreeableness -Individuals high in agreeableness are likely to comply with team goals even if these goals conflict with their own self-interest. Thus, in work teams with higher mean levels of agreeableness there will be strong compliance with team goals and high levels of cooperation. Accordingly, we expected higher task cohesion in work teams with higher mean levels of agreeableness.

Methods

Participants and Measures

A total of 102 handball top athletes (selections) participated in the study, aged between 16 and 35 years (M = 20.34; SD=4.75 years). From the total number of the participants, 52 are male and 50 are female, distribute by the following categories: junior (n = 35, 18 men and 17 female), Junior B (n = 32, 16 men and 16 female) and seniors (n = 35, 18 men and 17 female).
Task Cohesion. Cohesion was measured by using the Portuguese version of *Group Environment Questionnaire*, (GEQp, Mendes, et al., 1993). The GEQ is a 18 item questionnaire that assesses four dimensions of cohesion: Individual Attractions to Group: – Social - ATG-S (e.g. "some of my best friends are on this team"); and Task - ATG-T (e.g."I don't like the style of play on this team"); Group Integration – Social - GI-S (e.g."Our team would like to spend time together in the off season") and Task- GI-T (e.g. "Our team is united trying to reach its goals for performance"). Participants answered in a 9-point Likert scale, ranging from 1(*strongly disagree*) to 9 (*strongly agree*). Thus higher scores reflect higher perceptions of cohesion. In terms of internal consistency we found adequate values for both subscales: ATG-T, α= .65; IG-T, α= .75.
Personality. To assess personality we used NEO Personality Inventory (NEO-PI, McCrae e Costa, 1990), assessing the Big Five factors of personality. The 240 items measure the five scales, which includes Neuroticism (N), Extraversion (E), Openness to Experience (O), Agreeableness (A), and Conscientiousness (C). All factors presented good reliabilities, ranging from .81 to .53. Participants were asked to respond to the series of questions concerning how one behaves, feels, and acts. An example question is ''I am not a worrier'' (neuroticism question). For neuroticism, high scores reflect greater levels of emotional stability. Each of these five personality dimensions is scored according with the manual.

Procedures

Data was collected after explaining our goals to the teams head coaches, and after obtaining legal authorization (Federation and coaches). Athletes were briefed in the meeting rooms, about the nature of the study and all concepts were clarified beyond any doubts before completing the questionnaire. Confidentiality was also guaranteed. Data was analyzed by means of descriptive statistics to characterize participants (mean and SD). After it was screened for normality with Kolmogorov-Smirnov test. In order to analyze the relation between concepts, we used Pearson test and for comparisons, the T-Student. All analysis were processed using Statistical Package for Social Sciences (SPSS for Windows, version 20.0). A significance level of 5% was adopted for the study.

Results and Discussion

The mean differences between Openness to Experience (O), as well as between individual attraction (ATG-T), integration in the group associated to the task (GI-T) and social (GI-S), for and both male and female genders, revealed to be significant ($p < 0.01$). In other words, females perceive themselves to be higher on autonomy and to comply with new experience, more attracted to the group and integrated in it, as far as task is concerned, and also more socially integrated in group than male athletes.

Table 1. *Female and Male personality and cohesion values*

	Female		Male		Total	
	Min-Máx	M (SD)	Min-Máx	M (SD)	Min-Máx	M (SD)
Personality						
N	65-145	112,96 (17,08)	78-141	107,40 (14,26)	65-145	110,16 (15,86)
E	89-138	122,02 (9,04)	103-149	123,67 (11,38)	89-149	122,86 (10,28)
O	102-148	130,42 (10,92)*	115-141	126,42 (9,06)*	102-148	128,38 (10,17)
A	87-145	124,08 (12,98)	93-151	123,11 (10,78)	87-151	123,58 (11,86)
C	82-147	124,92 (14,44)	100-151	125,34 (13,49)	82-151	125,13 (13,90)
Cohesion						
ATG_S	4,2-9	7,40 (1,35)	2,25-9	7,01 (1,24)	2,6-9	7,20 (1,30)
ATG_T	4,5-9	8,19 (1,02)*	2,75-9	7,47 (1,37)*	3-9	7,82 (1,26)
GI_S	3-9	6,91 (1,50)*	3-9	6,30 (1,56)*	2,75-9	6,60 (1,56)
GI_T	5-9	7,16 (1,21)*	2-9	6,60 (1,65)*	2,75-9	6,87 (1,47)

*Note: Neuroticism (N), Extraversion (E), Openness to Experience (O), Agreeableness (A), and Conscientiousness (C), Individual Attractions to Group – Task (ATG_T), Individual attractions to the group social (ATG-S), group integration-task (GI-T), and group integration-social (GI-S).*p=0.05 **p=0.01*

For the total sample, in the association among cohesion and personality in handball athletes, we verify that there is a significant positive correlation between agreeableness and individual attractions to the group –Task (0,27, p≤0,01).

On cohesion, all factors are positively correlated. With regard to personality, we found that Conscientiousness correlated significantly in a negative way with Neuroticism (-0.27) and positively with Agreeableness (0.34) for p ≤ 0.01. As said early for neuroticism, high scores reflect greater levels of emotional stability. The factor Openness to Experience correlates positively with Extraversion (0.32) and Agreeableness (.32).

Table2. *Correlation between Personality and Cohesion*

	ATG_S	ATG_T	GI_S	GI_T	N	E	O	A	C
ATG_S	1								
ATG_T	0,40**	1							
GI_S	0,50**	0,22**	1						
GI_T	0,57**	0,59**	0,55**	1					
N	-0,08	-0,05	0,32	-0,02	1				
E	0,06	-0,01	0,06	0,00	-0,14	1			
O	0,08	0,03	0,04	0,02	0,15	0,32**	1		
A	0,18	0,27**	0,17	0,17	0,16	0,13	0,33**	1	
C	0,07	0,10	0,02	-0,01	-0,27**	0,14	0,08	0,34**	1

*Note: Neuroticism (N), Extraversion (E), Openness to Experience (O), Agreeableness (A), and Conscientiousness (C), Individual Attractions to Group – Task (ATG_T), Individual attractions to the group social (ATG-S), group integration-task (GI-T), and group integration-social (GI-S).*p=0.05 **p=0.01*

For female athletes we found: significantly positive correlations between the variables ATG-S / GI-S (0.67) and ATG-S / GI-T (0.53) for p≤0.01. That means, Individual Attraction to Group - Task is positively associated with group integration in the task and social issues;

significant correlations between GI-S and GI-T (0.40, $p \leq 0.01$) which means that integration into the social group is positively associated with the group task integration, or group social integration is extremely connected with the task integration.

In terms of personality, factors Extraversion and Openness to Experience (0.40, $p \leq 0.01$) are significantly positively correlated, ie, extroverts are more receptive to new ideas. The factor Agreeableness is positively correlated with the factors Extraversion (0.28, $p \leq 0.05$), Openness to Experience (0.54, $p \leq 0.01$) and Conscientiousness (0.41, $p \leq .01$), which makes this one of the most important personality factors in terms of handball female teams development.

Table3. *Cohesion and Personality correlation in male and female*

	Feminino									Masculino								
	ATG-S	ATG-T	GI-S	GI-T	N	E	O	A	C	ATG-S	ATG-T	GI-S	GI-T	N	E	O	A	C
ATG-S	1									1								
ATG-T	,08	1								**,63****	1							
GI-S	**,67****	,04	1							**,30***	**,28***	1						
GI-T	**,53****	**,36****	**,40****	1						**,60****	**,68****	**,62****	1					
N	-,16	-,02	-,12	-,09	1					-,05	-,21	,13	-,05	1				
E	,10	,05	,11	-,01	-,04	1				,06	-,01	,06	,03	-,23	1			
O	,02	,05	-,02	-,11	,21	**,40****	1			,12	-,08	,03	,06	-,01	**,32***	1		
A	,26	**,28***	,17	,07	,20	**,28***	**,54****	1		,09	**,29***	,17	,274*	,11	,01	,04	1	
C	,18	,19	,17	,06	-,13	,12	,10	**,41****	1	-,04	,05	-,11	-,07	**-,44****	,16	,08	,25	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

For male athletes, like for the all group we found significantly positive correlations between all group variables. That means, man value all aspects of team performance. In terms of personality, as in female athletes, factors Extraversion and Openness to Experience (0.40, $p \leq 0.01$) are significantly positively correlated, ie, extroverts are more receptive to new ideas. The factor Conscientiousness is negatively correlated with the factor Neuroticism (-0,44, $p \leq 0{,}01$), which makes this correlation an important issue to attend in future.

For female and male athletes we found a positive significant correlation between Agreeableness and Individual Attractions to Group – Task (0,28, $p \leq 0{,}05$), that means, female and male handball athletes high in agreeableness are likely to comply with team goals even if these goals conflict with their own self-interest. Thus, in working teams with higher mean levels of agreeableness there will be strong compliance with team goals and high levels of cooperation.

Conclusion

From the results of this study, we conclude that personality and group cohesion are mostly independent, for both female and male handball players. The only relation that we found tells us that individuals with high levels of agreeableness are more likely to comply with team goals.

Male and female athletes are different in their approach to team organization, with males more balanced between social and task, and females with higher global values, but more task oriented, which may indicate less social attraction.

Hence, work teams with higher mean levels of emotional stability will report greater task cohesion. On the other hand, when only one team member rates high on autonomy and others are the followers (low on autonomy), this may create task cohesion in the group, so we expect a positive relationship. The more similar team members are in terms of conscientiousness, the higher the team's task cohesion will be. Accordingly, we expected higher task cohesion in work teams with higher mean levels of agreeableness.

One limitation of this study was the reduced number of teams involved, making it impossible to analyze the team composite personality, which may lead us to different interaction with group cohesion

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ANALYSIS OF THE COMPETITIONAL BALANCE IN EUROPEAN WOMEN HANDBALL

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Summary
In order to obtain the most important television rights is necessary, first, an analysis of the national championship, at the first female echelon. One of the criteria for analyzing national championship is the competitive balance, because balance is crucial in uncertaintly sporting results.

Keywords
Competitional balance, NAMSI index, GINI index, women handball

Introduction

First of all, in order to obtain the most important television rights, it is required an analysis of the national championship, the first echelon, both for men and women. One of the criteria for analyzing national championship is the competitive balance, because balance is crucial in the uncertaintly of the sports results.

In the last thirty years, the investigations focused upon the economic involvement of the sports, increased a lot, all these investigations had to do with the analysis of the north American professional sports. These investigations concluded that the presence of the perfect team, which defeat all the opposite teams, eliminate the spirit of competition, and, implicit, the diminution of the audience' interest for that competition. As a result, the monopoly of a team being in championship, during many seasons, is a real disaster for that championship and also for the sports.

We can conclude: the more a championship becomes more interesting, and the fight for the victory is stronger, the more viewers will buy tickets, the more television will be interested to telecast that championship, and the more sponsors will be interested to invest in that sport.

The competitional balance occurs on several levels:
- *on the game itself* – the attractiveness of the game is higher if the final result is undecided until the last seconds of the competition (a game is more interesting if the final result is 23-22, than 44-10);
- *on the level of the championship*- the competitional balance does not allow that a team or a group of teams to detach to the rest of the platoon in the beginning of the competition, and the

fight for the victory lasts until the last stage of the competition, the difference score between the woman winner and the last woman qualified is minimal;
- *on the qualifying of the international competition* – some groups are unbalanced, but, generally, the competitional balance exists;
- *on the level of the history* – generally, only some teams can win the championship.

Therefore, the competitional balance splits in:
- the balance of the game;
- the balance of a competitional season;
- the balance of a championship.

Further, we will focus upon the temporary balance and upon the championship balance. Ideally speaking, a season is balanced when each team wins half of the games of a season and loses the other half or all the games from a season will end with the same score. So, in both situations, all teams will have the same score at the end of the season.

Methods

In order to compare different competitional seasons of the same championship and in order to make a correct evaluation of the championship during a long period of time, we need to find some methods of measurement valid for all cases.

The percentage of wins

The wins and the equal scores from the season are counted for a team. There is one point for each team and 0,5 points for an equal score. After all these points are gathered, they are divided to the number of the games to obtain the percentage of wins of a team from a competitional season. The result will be between 0 and 1. To interpretate, the more the value is closer to 1, the more that team had more wins during a season. The percentage of wins is a very important factor because with its aid will be calculated all the factors from which the championship is analyzed.

The amplitude

The amplitude means the easiest measure of the competitional balance, the difference between the percentage of wins from the first and the last qualified. The more this difference is bigger, the more the competitional balance is smaller.

The variation factor of the percentage of wins

The variation factor is a measure of the relative dispersion, in contrast to standard deviation, which is an absolute measure. The variation factor means the approximate percentage of the report between the standard deviation and the arithmetic average, and the formula is:

$$CV = \frac{S}{M} X100$$

CV – the variation factor
S – the standard deviation of a the percentage of wins from a season
M – the average of the percentage of wins from a season

This percentage allows us to compare the variation of different competitional seasons. The more the CV is smaller, the more the analyzed dates are unitary. So, through this factor, we can both analyze and compare the unitary of the different competitional seasons. In terms of the scale of estimation of the CV we can use the following values:

- high unitary: CV < 15%
- moderate unitary: 15% < CV < 25%
- low unitary: 25% < CV < 35%
- lack of unitary: 35% < CV

The NAMSI factor

In order to compare the won games during several seasons we need an adaptation of a method of measurement, equal for all situations because the number of teams from the different competitional season is different. In order to clarify this thing, we will give an example. Let's say that the worse script appears in this situation: a team wins all the games, the second team wins all the games except the games against the first team, the third team wins all the games except the games against the first two teams etc. So, the standard deviation of the won games percentage in a competition with 18 teams will be 0,305148. Let's say that the for the next season the number of the teams increased up to 20, and the script is the same. In this case, the standard deviation of the wins percentage becomes 0,303488.

So, if we add two more teams, the measure of uncertainty decreases, which gives the impression that this improved. This thing is not fair, because we will know who wins. So, the worse script is the one which we can predict who will win the game.

We propose the National Measure of the Seasonal Imbalance (NAMSI):

$$NAMSI = \frac{sd_s - sd_{min}}{sd_{max} - sd_{min}} = \frac{\sqrt{\frac{\sum_{i=1}^{n}(w_i - 0{,}5)^2}{n}}}{\sqrt{\frac{\sum_{i=1}^{n}(w_{imax} - 0{,}5)^2}{n}}} = \sqrt{\frac{\sum_{i=1}^{n}(w_i - 0{,}5)^2}{\sum_{i=1}^{n}(w_{imax} - 0{,}5)^2}}$$

i = team;
n = number of teams;
w_i = the wins percentage of the i team
w_{imax} = the predictable wins percentage of the i team;

To interpretate, the more the NAMSI value is closer to 1, the more that championship is more unbalanced.

The number of teams from Top 3 in the consecutive years

In order to measure dynamically I chose the TOP K. This ranking does not have problems with the advance and the retrogradation, like other parameters and further it takes into consideration more teams. The K chose and the number of years taken into consideration can be arbitrary. I chose the TOP 3, because in Europe there are two or three teams in each championship considered to be crucial. The taking into consideration of more teams weakens this TOP because the position 4 and 5 change more often. So, the using of TOP 3 is more fair to designate the crucial teams from Europe.

We will calculate this top during a period longer than three years because we can expect that the viewers to take into consideration this period when they think at the crucial position of a team. The minimal number of seasons taken into consideration is 3-9. Probably, the same three teams can enter in top 3 during a period of three years. So, the period expands up to 9 years, because it is less probably that in this period to be the same three teams in TOP 3. In this paper, I took two intervals from 5 consecutive competitional seasons as a period of reference (02 – 03 up to 06 – 07 and 07 – 08 up to 11 – 12).

The GINI factor

Apart the crucial position of these three teams, we also need an unit which concentrates upon the championship. We expect that the TOP 3 to be dominated from the same teams, but it is possible that the championship changes. The Gini factor was initially developed to measure the incomes inequity, but it also can be used in this context.

The promotion and the retrogradation of the teams change the structure of the championships, the adaptation of the number of teams specific to each competitional season, the change of the name, the fusions or the abolish of teams make this thing very difficult. The number of titles won by a team is weighted by the number of years spent in the first league. We believe this thing because the championship in which a team wins 10 titles in 40 years is less unbalanced from the competitionaly point of view than that in which a team wins 10 titles in 20 years.

We will use the Brown formula to calculate the GINI factor:

$$G = 1 - \sum_{i=0}^{k-1} (y_{i+1} + y_i)(x_{i+1} - x_i)$$

Y_i – the cumulative proportion of champions titles ponderated with the number of years in the first league;
X_i – the cumulative proportion of the number of teams;
k – the number of teams

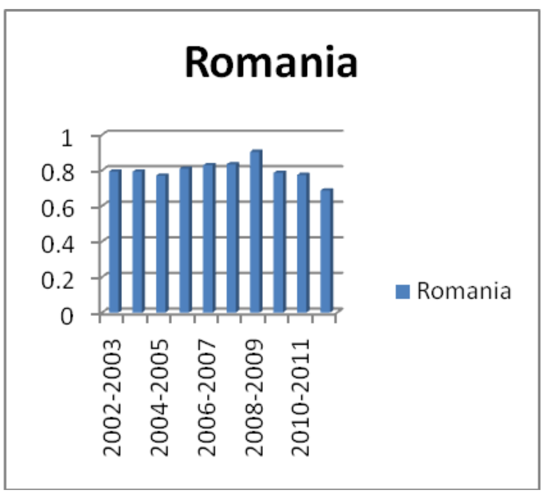
To interpretate, the more the value of the factor GINI is closer to 1, the more that championship is unbalanced.

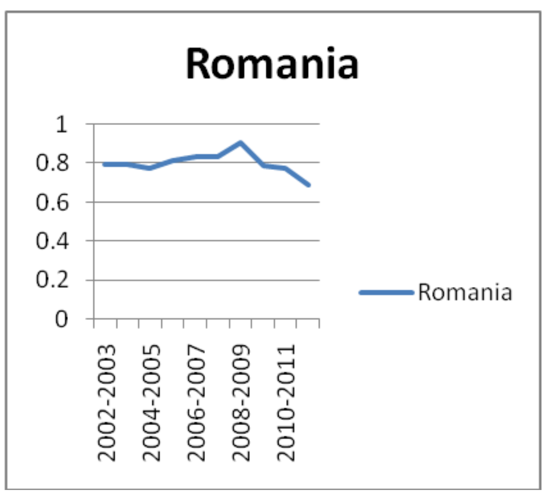
Results

In the table nr. 1 is represented the variation of the number of teams participated at the championships from the period taken into consideration:

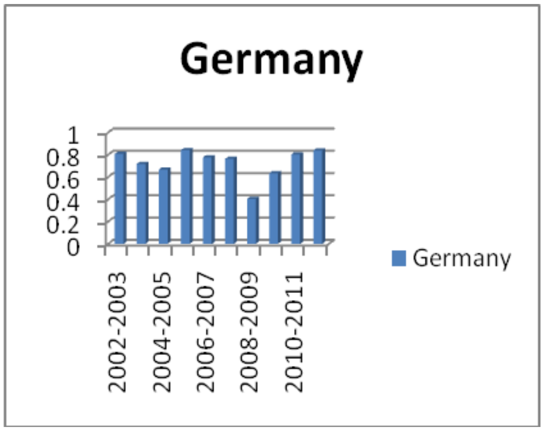
	Romania	**Germany**	**Austria**	**Greece**	**Cehia - Slovacia**
2002 – 2003	12	14	10	10	13
2003 – 2004	14	12	9	10	12
2004 – 2005	14	12	9	10	11
2005 – 2006	14	12	9	10	12
2006 – 2007	14	12	10	10	12
2007 – 2008	13	12	12	10	12
2008 – 2009	14	12	11	10	11
2009 – 2010	14	12	11	10	12
2010 – 2011	14	12	12	10	14
2011 - 2012	12	12	12	10	13

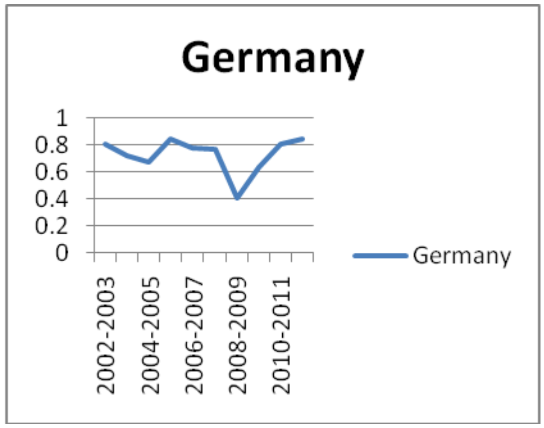
In the following graphics will be presented the variation of the NAMSI factor for each championship for the period taken into consideration. The graphics are presented in columns, in order to highlight the annually values also in the form of a curve, to highlight the variation values of the NAMSI factor from year to year.



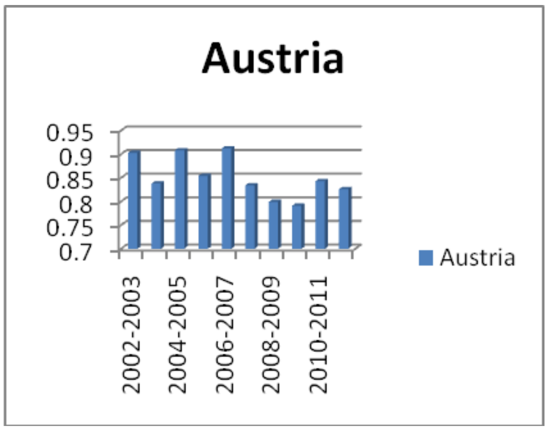


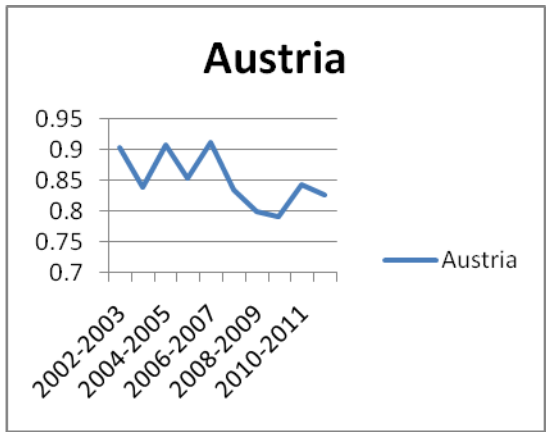
The graphics 1 and 2 – *The variation of the NAMSI factor in the women championship from Romania*



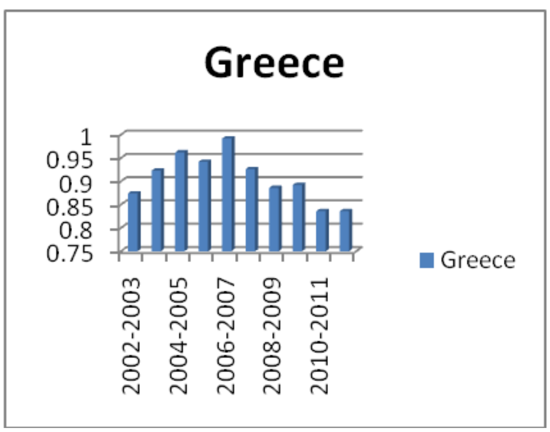


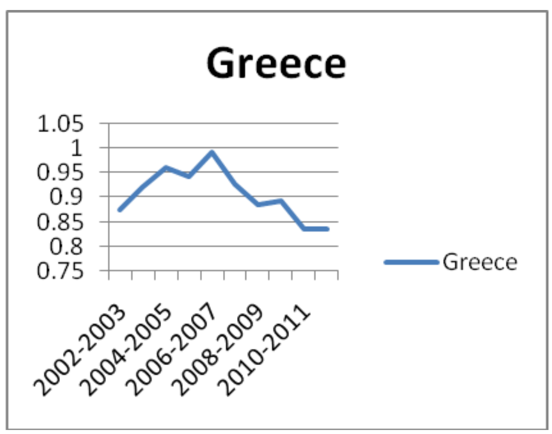
The graphics 3 and 4 – *The variation of te NAMSI factor in the women championship from Germany*



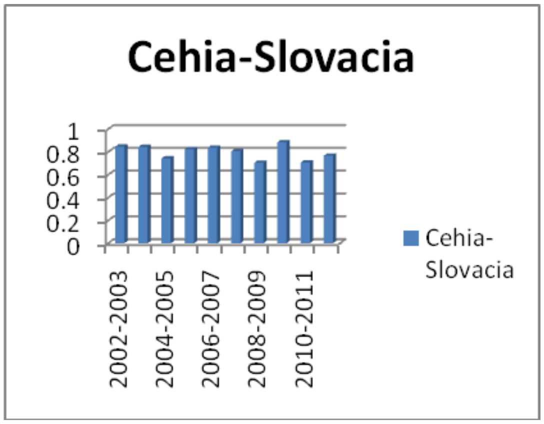


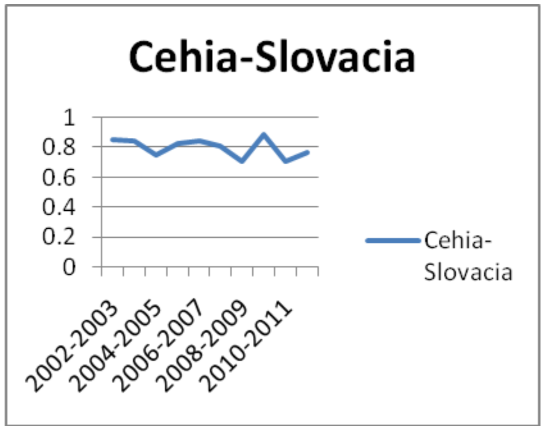
The graphics 5 and 6 – *The variation of the NAMSI factor in the women championship from Austria*





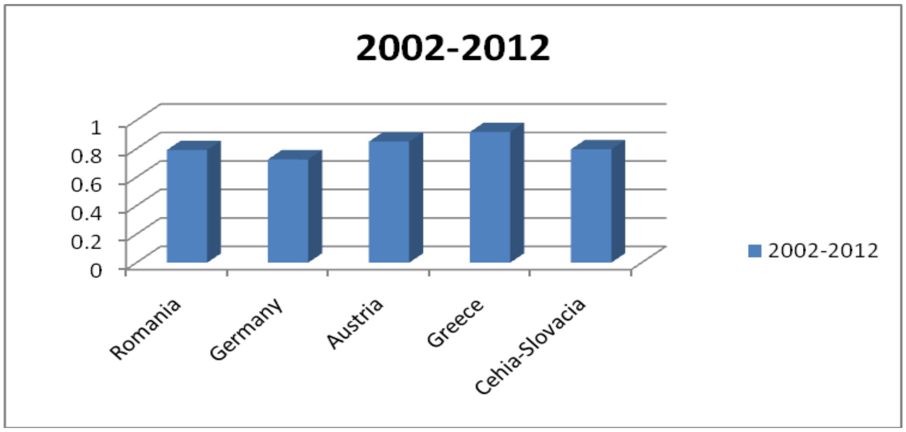
The graphics 7 and 8 – *The variation of the NAMSI factor in the women championship from Greece*





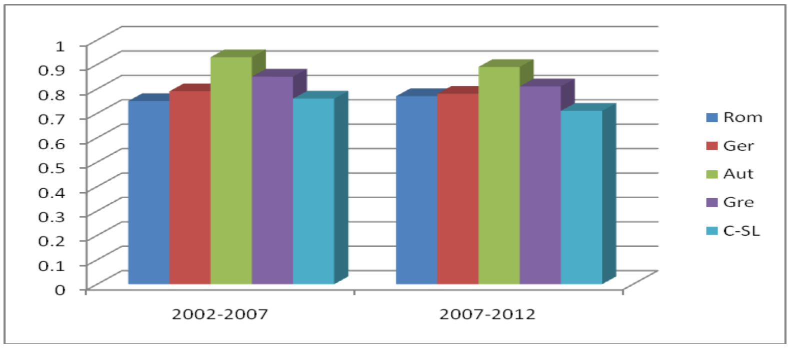
The graphics 9 and 10 – *The variation of the NAMSI factor in the women championship from Greece*

In the next graphic I made the average of the NAMSI factors for the five championships taken into consideration to highlight the most unbalanced championship during the 10 years taken into consideration.



The graphic 11 – *The values average of the NAMSI factor for the 10 years taken into consideration*

Further, we will represent graphically in the form of columns the variation of the GINI factor for the two periods of five years taken into consideration



The graphic 12 – *The variation of the GINI factor for the two periods of five years.*

Conclusions

After the analysis of the graphics 1-10, we can say that:

- the women championship from Romania has a tendency towards balancing, especially in the last years; there is a very big unbalance in 2008-2009 (0.834), because the best balanced competition was in 2011-2012 (0.687)
- in Germany, the women championship is quite balanced, it had its best balance in 2008-2009 (0.404) and a less balance in 2005-2006 (0.842)
- in Austria, we can say that it is a unbalanced championship, it had its best balance in 2009-2010 (0.791) and a less balance in 2006-2007 (0.912)
- in Greece, the women championship is totally unbalanced, it had its best balance in 2002-2003 (0.874) and a less balance in 2004-2005 (0.962)
- the championship from Czech and Slovakia is quite balanced, it had its best balance in 2008-2009 (0.705) and a less balance in 2002-2003 (0.847)
- the competitional unbalance variates from year to year like a wave, with a small tendency of decrease in Romania, Austria and Greece, and with big tendency of growth in Germany, Czech and Slovakia

After the analysis of the graphic 11, we can say that the best balanced championship is the german championship, and the less balanced championship is the one from Greece. After the analysis of the graphic 12, we can say that the austrian championship the tendency of domination of the team from TOP 3 is higher, but with a small tendency of decrease in the second period. We can say the same things above about the championships from Greece, Czech and Slovakia. Instead, in the championships from Romania and Germany, the tendency is to increase the domination of the teams from TOP 3 in the second period.

From the point of view of the sales of the media rights it can exist two sistems:

- *the sistem of individual sale*- in each club has and sales the media rights for the match that it organizes
- *the sistem of collective sale* – the professional league sales the image rights of the members, then the incomes are distributed by these members (this sistem is available in almost all european countries).

The collective sale of the media rights has as a major result the increase of the competitional balance at the level of the internal competition and the balancing of the performances from the championship.

The balancing of the internal competition has as a result the increase of the spectacular of the competition and, implicitly, the increase of the viewers, media and sponsors interesting for this competition. Another result of the balancing of the internal competition is the improvement of the scores of the national teams. Apart the collective distribution of the media rights, an unit that can raise the competitional balance is the determination of the correct number of teams that participate in the internal competition.

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ASSESSMENT OF PSYCHOLOGICAL SKILLS IN YOUNG ELITE FEMALE HANDBALL PLAYERS

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Summary
The aim of this study was to know psychological characteristics of young elite female handball players using the C.P.R.D. questionnaire, and to establish possible differences based on years competing. The obtained results show that these young female handball players have similar psychological characteristics to other sports players. Players with more year of competitive experience showed higher scores in different psychological skills assessed. Nevertheless, only significant differences were found between more experienced players and less experienced players (years competing) in mental skills scale ($p \leq 0,05$).

Keywords
Woman handball players, C.P.R.D. questionnaire, psychological assessment, psychological skills

Introduction
The level of demand to which they are subjected athletes is growing, making it necessary to have sufficient resources to cope with the increasing number and difficulty of sports competition. These situations test the coping resources and cognitive-behavioral resources and physiological of athletes, where the frequency and intensity of stressful stimuli leads many times to performance problems. Given these requirements, it is necessary to make a proper assessment of the resources of the athlete and the determination of "strengths" and "weaknesses" at psychological level as a key of sporting success (García, Estrany, & Cruz, 2004).

It is hoped that sports itself and previous experience contribute to the improvement of psychological skills in athletes, even when there has been no specific training of these. Following to (Martín, 2003) in an observational study of football teams which assesses psychological skills depending on the sport experience, argues that psychology skills profile belonging to the elite athletes are not innate but learned, and that most of the athletes who become experts in their sport's learned through years of practice. Later, Nicholls and Polman (2007) in a review of research on coping strategies in sport claim that athletes use a variety of strategies and that there is a greater range of the same when increasing experience sports. They mention a study by Gaudreau and Blondin (2002) where athletes (N=316) given a test that assesses coping strategies in competitive sport, and results showed that more experienced athletes use a greater representation of mental images against the less experienced.

However, Godoy-Izquierdo, Vélez, and Pradas (2007) conclude in their study that there are no significant differences in the domain of relevant psychological skills between novice and expert athletes, obtaining lower scores in as concentration control, activation control and self-confidence. A similar study investigates the level of mastery of psychological skills of young players of table tennis, badminton and football, through CHPCDC (Psychological Skills and Behavior in Sport Competition-Children-Youth Scale) with 41 athletes ranging in age from 9 to 18 years, and determined that there are no significant differences in the variables evaluated (concentration control, activation control, visualization, motivation, etc.) with regard to the experience in sport and competition (Godoy-Izquierdo, Vélez, & Pradas, 2009). Despite the existence of previous literature that analyzes psychological skills based on the experience of athletes, there are few studies in relation with this topic in handball. Thus, the aim of this study was to determinate psychological skills of young female handball players and compare the level of control over these skills considering their sporting experience (≤5, >5 years competing), using the C.P.R.D. questionnaire (Psychological Characteristics related to Sport Performance) by Spanish authors Gimeno, Buceta, and Pérez-Llantada (2001).

Methods

Participants

The total sample consisted of 137 young elite female handball players from 13 to 16 years (M= 14,25; SD= 0,74), which have been playing a mean of 8,66 years (SD=2,16), and a mean of 5,10 years competing (SD=2,18). All players competed in the highest league of their sports category, were selected as the best players of their sport category, belonged to the National Sporting Talent Program of the Royal Spanish Handball Federation, and commonly performed at least 3 training sessions per week plus one official match.

Assessment instrument

As data collection instrument were used the C.P.R.D. Psychological Characteristics related to Sport Performance questionnaire by Gimeno et al. (2001). This instrument was designed for psychological assessment of performance in sport. In terms of reliability this questionnaire has shown an acceptable internal consistency (Gimeno et al., 2001), both in total questionnaire (α= 0,85) and its scales: stress control (SC) (α= 0,88), influence of performance evaluation (IPE) (α= 0,72), motivation (M) (α= 0,67) and team cohesion (TCOH) (α=0,78), with the exception of the scale of mental skills (MSK) (α= 0,34). The answer of each question is graded on a 5-point Liker scale and also includes an option of response of this kind: "I do not understand".

Procedure

All players and their parents were informed about the procedures of the measurements and provided their written consent for participating according to the research policy of the Royal Spanish Handball Federation. All of them completed the questionnaire individually, accompanied by a personal data sheet.

Data analysis

All data are expressed as mean (SD), minimum, maximum and centiles (all data were checked for distribution normality and homogeneity with the Kolmogorov-Smirnov and Lilliefors test). Was obtained internal consistency of questionnaire scales using Cronbrach's alpha. Differences in the level of psychological skills related to performance based on years competing were compared by t de Student for independent samples. Effect size was calculated by Cohen´s *d* (Cohen, 1988). Statistical significance was set at $p \leq 0,05$. All analyses were done with SPSS version17.0.

Results

With our sample of female handball players, the internal consistency of the complete questionnaire was 0.75, a little bit lower punctuation that the one obtained in the original research (Gimeno et al., 2001), although it is considered acceptable according to the usual criteria (Nunally, 1978). However, were obtained internal consistency values that can be considered acceptable in each questionnaire scales.

Table 1 shows Cronbach´s alpha, descriptive statistic (mean, standard deviation, maximum and minimum), and maximum obtainable score, obtained by all players (N= 137) in each scale, as well as the mean score for each scale transformed on the basis of 10 point.

Table 1. Cronbach´s alpha, mean, standard deviation (SD), minimum, maximum, and maximum obtainable score, obtained by all the players (N= 137) in each scale, as well as the mean score of each scale transformed on the basis of 10 point.						
Scales	**Cronbach´s α**	**Mean (SD)**	**Min.**	**Max.**	**Max. obtainable score**	**Mean Score on the basis of 10 points**
Stress control (SC)	0,625	52,96 (11,55)	1	79	80	6,62
Influence of performance evaluation (IPE)	0,671	29,98 (7,41)	0	44	48	6,25
Motivation (M)	0,704	23,83 (4,48)	0	32	32	7,45
Mental skills (MSK)	0,705	22,31 (4,87)	1	34	36	6,20
Team cohesion (TCOH)	0,768	19,09 (3,34)	0	24	24	7,95

Since there are scores with other data on different samples of practitioners of other sports, and in order to make visible where our female handball players are placed relative to other sports, table 2 presents direct punctuations (D.P.) obtained by our female handball players and their corresponding centile. This Table 2 also reflects a comparison between the centile where is situated our sample based on direct punctuations obtained in our study, with respect to C.P.R.D. normative group centile (Gimeno et al., 2001) and those obtained in other studies with samples of indoor soccer players (Lecina, Peris, & Gimeno, 2010) and gymnastics (Jaenes, Carmona, & Lopa, 2010).

It is observed that handball player score are above the ones of the original sample in all scales. With respect to indoor soccer players, handball players have the higher scores in all scales except in motivation. Finally, it is noted how handball players and gymnasts show the same centile in all scales.

Table 2. Comparison between the centile where is situated our sample based on direct punctuations obtained in our study, with respect to the C.P.R.D. normative group centile and those obtained in other studies with samples of indoor soccer players and gymnastics.					
	Direct punctuations (D.P.) and its corresponding Centile in our study		**Centiles that our study would reach in other studies based on its direct punctuations**		
	D.P.	**Centile**	**Centile of the normative group (Gimeno et al., 2001)**	**Centile of indoor soccer players (Lecina et al., 2010)**	**Centile of rhythmic gymnastics (Jaenes et al., 2010)**
Stress control (SC)	54	50	70	59	50
Influence of performance evaluation (IPE)	30	50	75	60	50
Motivation (M)	24	50	80	45	50
Mental skills (MSK)	23	50	70	70	50
Team cohesion (TC)	20	50	65	55	50

Table 3 compare the means of the psychological variables assessed between the group who had more than 5 years competing in their sport (more experienced group), with the group who had 5 or fewer years competing. We have obtained statistically significant differences ($p \leq 0,05$) between groups in mental skills scale, being the players with more than 5 years competing those with greater punctuations in this variable. The effect size for mental skills scale (d= -0,40) is medium.

Table 3. Descriptive statistics and inferential based on competing experience (years competing).

Psychological variables	Years competing	N	Mean (SD)	d^1	*t*	*p*
Stress control (SC)	≤5	76	52,37 (12,41)	-0,11	-0,672	0,503
	>5	61	53,70 (10,43)			
Influence of performance evaluation (IPE)	≤5	76	29,49 (7,64)	-0,14	-0,865	0,388
	>5	61	30,59 (7,12)			
Motivation (M)	≤5	76	23,47 (4,89)	-0,18	-1,046	0,297
	>5	61	24,28 (3,88)			
Mental skills (MS)	≤5	76	21,49 (5,32)	-0,40	-2,249	0,026*
	>5	61	23,34 (4,05)			
Team cohesion (TC)	≤5	76	19,20 (3,51)	0,07	0,427	0,670
	>5	61	18,95 (3,14)			

*****$p \leq 0,05$
[1]To calculate the effect size were considered deviations combined (Cohen, 1988).

Discussion
After applying the C.P.R.D. and data analyze, it can be stated that reliability obtained for the whole questionnaire is acceptable (Cronbach's alpha= 0,75), comparable to that obtained in other studies (Gimeno et al., 2001; Jaenes et al., 2010).

Reliability obtained in each scale was, in general, similar to that obtained in the above studies. Our Cronbach´s alpha values are very near from those obtained in the original study (Gimeno et al., 2001). In this regard, our results were: IPE α= 0,671, M α= 0,704, and TCOH α= 0,768, and the results of the original study were: 0,72, 0,67 and 0,78, respectively. However, in Mental skills scale, we obtained **α=** 0,705, versus **α=** 0,34 in the above mentioned original study.

Referred to the scores of handball players compared with those obtained by other athletes using the same questionnaire, the results show that our female handball players get higher scores on all scales of the questionnaire that athletes of the research sample of Gimeno et al. (2001). Nevertheless, with respect to the sample of gymnasts analyzed by Jaenes et al. (2010) they obtained similar results. Whereas, with respect to the sample of football players analyzed by Lecina et al. (2010) were obtained mixed results, because our female handball players seem to have higher scores on all variables except on motivation.

The explanation for these results could reside in the specific characteristics of the sample evaluated by Gimeno et al. (2001) and by Lecina et al. (2010), where athletes were non-elite athletes, and also because the representation of handball players in the study of Gimeno et al. (2001) is not representative (0.6%).

Depending on the sport experience of the participants in the study (≤ 5, > 5 years competing) we found statistically significant differences in mental skills scale, obtaining more punctuation most experienced players. Although there are not statistically significant differences in other variables, higher scores are observed depending on the competitive experience, in stress control, influence of performance evaluation and motivation except in team cohesion. Although there is an inverse relationship on team cohesion scale (the most experienced players obtained lower scores than the less experienced players), the levels obtained in team cohesion scale are high, like those reported by Sosa (2008).

These results are consistent with the assertions of Martín (2003), wherein the improvement of psychological skills were explained by the age and sport experience, though not for the motivation variable. Also are in accordance with the study of Goyen and Anshel (1998), which concluded that more experienced athletes have better concentration and are better able to regulate their negative emotions to stressful events, compared with the less experienced athletes.

According to Godoy-Izquierdo et al. (2007) experience is important because creates learning, and contributes to the acquisition of technical and tactical knowledge, as well as improves psychological skills. The practice of sport, trial and error, etc., helps to learn and assimilate knowledge. However, there are studies in which their results are not according to the stated above, (Godoy-Izquierdo et al., 2007, 2009; Sosa, 2008), and thus, which are not in line with our results, where the athletes more younger obtained higher scores on some of the studied variables than the most experienced athletes.

Conclusions

The results obtained allow us to further intervene in the development of competencies based on these results, advising coaches or athletes, helping them in their training and providing global and appropriate psychological skills that enable them to cope with the growing demands with increasing their involvement in it. Besides, the C.P.R.D. questionnaire (Gimeno et al., 2001) has showed to be an useful tool to assess the domain level and psychological control skills in athletes.

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LEVEL DOMAIN OF PSYCHOLOGICAL SKILLS IN YOUNG WOMAN ELITE HANDBALL PLAYERS

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Summary
The study aimed to know psychological skills of young elite female handball players and to analyze possible differences in these variables considering their level of competitive experience, depending on the scores obtained in CHPCDC- Children and Youth Scale. The more experienced players showed lower scores on several psychological skills and also a lower total score. Therefore should be included in sports training, psychological skills training.

Keywords
Young female handball players, psychological assessment, psychological skills, psychological training

Introduction
The sport can be very important for the development of children because it promotes their overall development (bio-psycho-social), in addition to their athletic development. For these reasons, it is accepted that, if the sport has an appropriate structure, organization, characteristics and adult leadership, is highly suited to achieve these objectives (Godoy-Izquierdo, Vélez, & Pradas, 2007).

Moreover, athletic performance in any sport is a combination of ability and motor skill, technical, tactical, strategic and psychological aspects. For this, it is necessary long periods of preparation of the athletes in sport-specific skills. However, as the high level athletes distinguished relatively little in physical, technical or tactical, their different performances could be explained by the domain and control of psychological skills. The psychological preparation of athletes includes mental skills training to help or enhance their performance (Godoy-Izquierdo et al., 2007, p. 47). For Chen and Singer (1992), athletes need to learn a set of tools to manage their psychological resources independently and adapted to the demands of their sport in every moment and situation, both in training and in competition.

The individual identification of deficits and resources of each athlete, the degree of domain of the psychological skills and their specific needs, will help establish goals and design of psychological training plan. This will aim to develop mental skills that are considered important for each player, sport, etc. For this it is necessary to have appropriate instruments to obtain this information in young athletes. That is the case of *CHPCDC Scale* (Escala Infantil-Juvenil *de Habilidades Psicológicas y Comportamientos en el Deporte de Competición*, or Psychological Skills and Behavior in Sport Competition -Children-Youth Scale), by Godoy-Izquierdo, Vélez, Ramírez, and Andréu (2006a), or the *C.P.R.D.* Questionnaire (*Características Psicológicas relacionadas con el Rendimiento Deportivo, or* Psychological Characteristics related of Sport Performance), by Gimeno, Buceta, and Pérez-Llantada (2001) in Spanish language.

In English language there are many more instruments designed specifically to assess the level of mastery of psychological skills, as the Ottawa Mental Skills Assessment Tool-3-OMSAT-3

(Durand-Bush, Salmela, & Green-Demers, 2001), the Athletic Coping Skills Inventory-28-ACSI-28 (Smith, Schutz, Smoll, & Ptacek, 1995), Spanish version by Graupera Sanz, Ruiz Pérez, García Coll, and Smith (2011), Psychological Skills Inventory for Sports-PSIS (Mahoney, Gabriel, & Scott Perkins, 1987), currently PSIS-R5 (5th revision), among others.
The aim of this study was to know the psychological skills of young female handball players and compare the level of control over these skills considering their sporting experience (years competing), using an instrument designed specifically for psychological assessment of children and young people in Spanish population.

Methods

Participants

The study involved 139 young female handball players from 13 to 16 years old (M= 14,25; SD= 0,74), with a mean of 8,66 years playing (SD= 2,16), and a mean of 5,10 years competing (SD= 2,18). Of these, a total of 39 players completed a second measurement. In the first measurement they had a mean of 5,07 years of competitive experience (SD= 2,24), while in the second measurement they had a mean of 6,20 years competing (SD= 2,15). All players competed in the highest league of their sports category, were selected as the best players of their sport category, belonged to the National Sporting Talent Programme of the Royal Spanish Handball Federation, and commonly performed at least 3 training sessions per week plus one official match.

Assessment instrument

As data collection instrument we used the Spanish Questionnaire CHPCDC (in English, Psychological Skills Questionnaire and Behavior in Sport Competition - Children-Youth Scale), by Godoy-Izquierdo et al. (2006a) for the assessment of 21 variables and psychological skills in young athletes.

The CHPCDC consists of 45 items distributed in 21 subscales that assess both psychological behaviors such as self-regulation skills relevant in sport. The instrument collects information about the degree of experimentation and the level of mastery of different variables and psychological skills. The answers to each question are graduated in 5 options, each one of them includes a description of the different possibilities, and the athlete must mark the option that best suits her particular case. The answers are evaluated from -2 to +2, where 0 indicates a clear lack of knowledge or control over the ability, negative attitudes, or behaviors in the opposite line the ability. Positive values indicate a greater knowledge, positive attitudes, or level of mastery over the skill. Subscale scores are obtained by adding the scores of its items, and total score is obtained by adding the points of each subscale. The last question of the questionnaire is not included in total score because it is an open question where the athletes listed in order of priority the psychological skills they would like to improve and work on a future psychological training. The 21 subscales are: basic Motivation, activation (energy), competitive anxiety, influence of the result (successes and failures coping), negative thinking, positive thinking, controllability for successes, controllability for failures, visualization, concentration, reflexivity-impulsivity, self-assessment of performance (differences training-competition), daily motivation, competitive motivation, self-confidence, peer relationships, cooperation and cohesion in the team, relationship coach, parent performances, fair play and ethical behavior, self-awareness, and expectations.

Results have immediate implications related to psychological training and integral sports training for athletes, and in the identification and training of talented athletes, making possible to obtain a profile of these young athletes. However, it is always necessary to complement the information obtained with other information obtained from other assessment strategies, as interview and athlete´s observation, or interviews to their coaches, etc., and also applies in order to test the effectiveness of the intervention in medium-long term. Remark that there is also a version of this questionnaire in interview format (Godoy-Izquierdo, Vélez, Ramírez, & Andréu, 2006b).

Procedure

All players and their parents were informed about the procedures of the measurements and provided their written consent for participating according to the research policy of the Royal Spanish Handball Federation. All of them completed the questionnaire individually, accompanied by a personal data sheet.

Data analysis

According to the Kolmogorov-Smirnov test, data were not normally distributed for all measures in this study and therefore, nonparametric statistics were used. To appreciate the differences between the first and second measurement we used the Wilcoxon test for related samples. We used levels of significance of $p \leq 0{,}05$ and $p \leq 0{,}01$ in the statistical analysis. All analyses were done with SPSS version 17.0.

Results

Table 1 shows the descriptive results (mean, standard deviation, minimum, maximum, and maximum obtainable score) obtained by the sample in each of the subscales and in the full CHPCDC as well as transformed mean score on the basis of 10 points, to help the reader better analyze and compare the results between the different subscales. It can be observed that the total score is relatively low (42,68) compared to the maximum total score (90) that can be obtained in the questionnaire. As for the mean scores on the subscales, some values are close to the maximum that can be obtained in those subscales, while other cases are far apart.

Table 1. Mean, standard deviation (SD), minimum, maximum, and maximum obtainable score, obtained by all the players (N= 139) in each of the 21 subscales, as well as score of each subscale transformed on the basis of 10 points.

	Subscales and Total score	**Mean (SD)**	**Min.**	**Max.**	**Max. obtainable score**	**Mean Score on the basis of 10 points**
a	Performances of parents (PPARENTS)	3,37 (1,01)	-2	4	4	8,42
b	Expectations (EXP)	1,60 (0,90)	-2	2	2	8
c	Relationship with coach (RCOACH)	3,04 (1,13)	-1	4	4	7,6
d	Daily motivation (DMOT)	1,37 (0,65)	-2	2	2	6,85
e	Activation (energy) (ACT)	6,80 (3,28)	-5	10	10	6,8
f	Fairplay and ethical behavior (FAI)	1,34 (0,66)	-2	2	2	6,7
g	Self-awareness (S-AWAR)	1,27 (1,12)	-2	2	2	6,35
h	Self performance evaluation (differences training-competition) (S-P-EVAL)	1,20 (0,94)	-2	2	2	6
i	Competitive motivation (CMOT)	2,24 (1,17)	-2	4	4	5,6
j	Relations with partners, cohesion-cooperation in the team (COH)	1,09 (1,00)	-2	2	2	5,45
k	Negative thinking (NTHINK)	2,14 (1,19)	-2	4	4	5,35
l	Concentration (CONC)	4,20 (1,89)	-2	8	8	5,25
m	Positive thinking (PTHINK)	4,01 (3,39)	-8	8	8	5,01
n	Basic motivation (BMOT)	0,84 (0,51)	-1	1	2	4,2
ñ	Reflexivity-impulsivity (REIM)	1,63 (1,51)	-4	4	4	4,07
o	Controllability for failure (CFAIL)	0,75 (0,48)	-0,4	1,6	2	3,75
p	Controllability for success (CSUCC)	0,68 (0,42)	0	2	2	3,4
q	Visualization (VIS)	1,29 (2,28)	-4	4	4	3,22
r	Competitive anxiety (CANX)	3,53 (3,98)	-11	12	16	2,2
s	Self-confidence (S-CONF)	0,25 (1,37)	-3	4	4	0,62
t	Influence of results (coping of successes and failures) (IRES)	0,05 (0,67)	-2	2	2	0,25
	Total score	42,68 (13,24)	-23,20	42,68	90	4,74

Figure 1 shows total score obtained in CHPCDC in the two different time-points assessment.

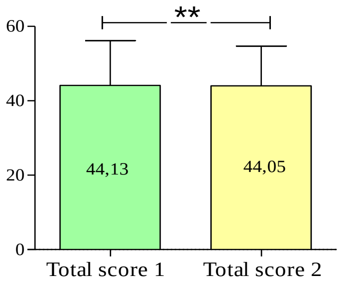
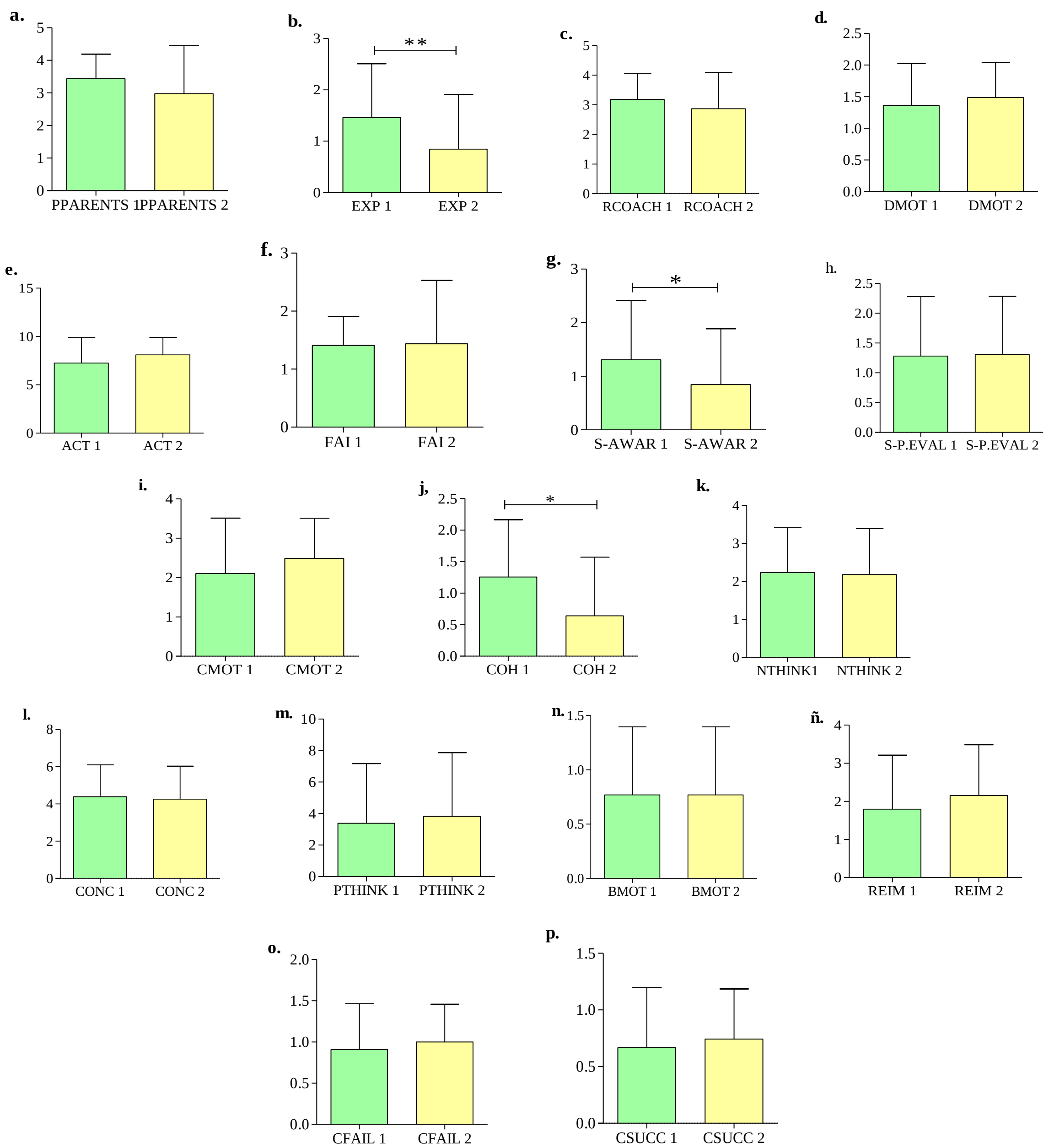


Figure 1. *Total score obtained by the female handball players (N= 39) in CHPCDC in the first and the second measurement (**p≤ 0,01).*

Figure 2 shows subscales scores obtained in CHPCDC in different time-points assessment.



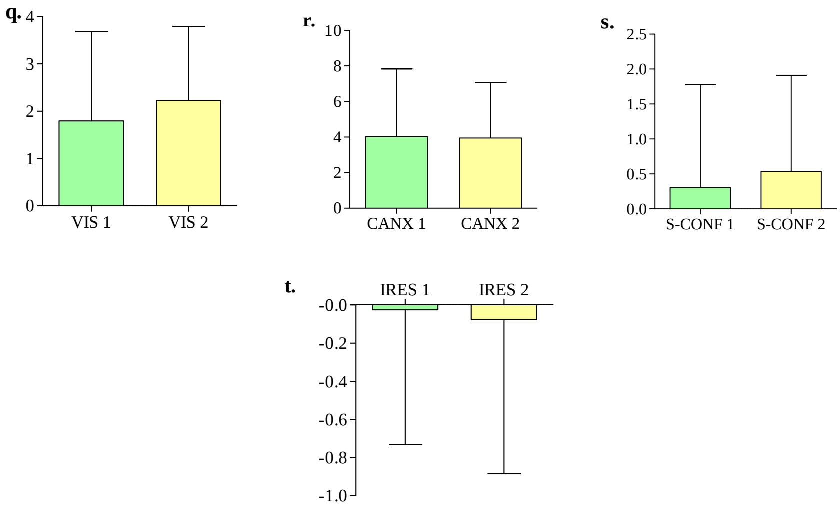


Figure 2. *Scores obtained by the young elite female handball players in CHPCDC subscales in different time-points assessment (*p≤ 0,05; ** p≤ 0,01).*

Statistically significant differences were observed in expectations (figure b, $p \leq 0{,}01$), self-awareness (figure g, $p \leq 0{,}05$), and in relations with partners and cohesion-cooperation in the team (COH, figure j, $p \leq 0{,}05$), being lower results obtained in the second measurement.

Discussion

The results show that these young female handball players have mean scores below the mean value of the subscale , and therefore less domain and control , in the following seven variables: influence of results, self-confidence, visualization, controllability for success, controllability for failures, reflexivity -impulsivity, and basic motivation. On the contrary, it should be noted positively the low values obtained in competitive anxiety subscale. On the other hand, have a moderate domain and control as higher mean scores obtained in these six variables: self-evaluation of performance (differences training -competition), competitive motivation, relationships with peers and cohesion-team cooperation, negative and positive thinking, and concentration. Finally, the greatest mastery and control occurs in the 7 variables that obtained the highest mean scores, they are listed from highest to lowest: performances of parents, expectations, relationship with the coach, daily motivation, activation, fair play and self-awareness.

These results have been reported in other studies by (Godoy-Izquierdo et al., 2007; Godoy-Izquierdo, Vélez, & Pradas, 2009) where racquet sports and soccer players, as assessed by the same instrument (CHPCDC) obtained similar results to ours. Also our results are in line with other studies conducted with young players (Jaenes, Carmona, & Lopa, 2010; Lines, Schwartzman, Tkachuk, Leslie-Toogood, & Martin, 1999; Sosa, 2008).

In the other hand, one of our aims was to test the influence of competition experience in the sport in relationship with the level of domain and control of psychological skill. Godoy-Izquierdo et al. (2007) indicate that experience in sports could help in the development of these skills, even without specific training. However, this relationship is not clear, there are authors in agree with this statement (Singer, 1998), while others, on the contrary, found no difference between more experienced players and less experienced players (Lines et al., 1999). Our results do show statistically significant differences, but only in these three variables: relations with partners and cohesion-cooperation in the team, self-awareness and expectations, and although there is no statistical differences in the other variables, there is a similar trend, where less experienced players show higher scores on different variables. These results partially agree with those presented by Sosa (2008), where were found significant differences between athletes with great, moderate and little practice or experience, obtaining the highest scores the group with much practice in self-esteem, self-confidence and narcissistic motivation, while the group of little practice obtained the highest scores in cohesion and social affiliation.

Conclusions

The low scores obtained in several variables point out the convinience of psychological training, primarily in these variables: influence of the results, self-confidence, visualization, controllability for success, controllability for failure, reflexivity-impulsivity, and basic motivation as part of the comprehensive training of athletes, with the goal of providing appropriate psychological skills that enable them to cope with the growing demands of the sport while increasing their involvement in it.

Acknowledgements

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