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Scientific Approach to the Player's Environment-

From Participation to the Top

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FOREWORD

Michael Wiederer
EHF President

Since 2011 the European Handball Federation (EHF) in cooperation with the Union of University Handball Teachers (UUHT) has succeeded in bringing professional, medical, and scientific experts together to share their research, data, and ideas on the physical and mental welfare of the professional athlete in the areas of performance and training.

Stemming from a renewed focus in the areas of physiological and psychological health, and its relation to the condition of athletes and injury prevention, the EHF Scientific Conference was created. In 2011 we focused on sports training and medicine; in 2013 the emphasis was on women's handball and knee injuries. At the 2015 convention, we were thrilled to host numerous presentations on the medical aspects of training, injury prevention, and prophylactic training. The theme of the 2017 symposium is the player's health, as well as social environment, in amateur and professional handball with a special focus on equipment issues.

To the fourth edition of the EHF Scientific Conference, the European Handball Federation welcomes speakers Michael Musalek (AUT), Leonard Achenbach (GER), Susana Póvoas (POR), and Piotr Kaczmarek (POL) who will deliver the keynote addresses covering social aesthetics; an injury profile of the 2017 Beach Handball European Championship; the biomechanical profile of the shoulder; and a profile of the Handball4Health project promoting handball as a sport for all. Also returning to the forum are medical experts Jesper Bencke (DEN), and injury specialist Lior Laver (ISR), who will deliver presentations on injuries and the effects of fatigue.

With over thirty speakers and three focal points – medical, physiological, and biomechanical, we once again immerse ourselves in a number of academic approaches aimed at refining our understanding of the needs of the performance athlete. Moreover, such understanding cements the necessity of the ongoing scientific exploration in the field. Przemysław Lubiatowski, an orthopaedic and trauma specialist, joins the conference presenting 'Recovery and Return to Sport From Shoulder Injury and Surgery' in the second medical session.

As we strive for the intellectual knowledge that in turn leads us to a deeper comprehension, we can hope to attain significant advancements when it comes to the prevention of injury and the safeguarding of our athletes.

I now take this opportunity to thank the members of the Preparatory Organising Committee and the members of the EHF Scientific Network for diligently supervising and overseeing the arrangement of this essential platform that was also made possible with the engagement of the EHF Competence Academy & Network. I hope that the visitors and speakers at the 4th EHF Scientific Conference through sharing ideas will find insight and inspiration to continue in their endeavours to bring a new level of cognisance to the medical aspects in handball.

Michael Wiederer
EHF President

Table of Contents

Poster Presentations

Notes by the Editor

* This book comprises of the full articles that were provided by the authors. A number of further articles and topics were presented at the Conference in Budapest but have not been submitted by their authors. Though the full version of those articles is not available in the present documentation, their abstracts can be found towards the end of the book, under “Further topics presented at the Scientific Conference”, (p. 183-214).

* For reasons of comprehension and/or grammatical coherence some of the article titles have been grammatically and/or syntactically altered, thus differing from the version submitted by the author.

* The articles are published as submitted by their authors. No grammatical or syntactical corrections have been implemented. Spelling also varies, based on the authors’ preferred form of English (British or American).

* To serve editing purposes, the outline form of some articles may have been altered. However, the content remains unaffected.

* A useful list of e-mail addresses of Conference presenters and/or article authors can be found at the end of this book.

BEACH HANDBALL IS SAFER THAN INDOOR HANDBALL: INJURIES DURING THE EUROPEAN BEACH HANDBALL CHAMPIONSHIP 2017

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Summary
This first study about beach handball shows a lower incidence of time-loss injuries and a higher incidence of skin injuries, especially to the lower extremities, compared to literature of indoor team handball. Further research in this developing sport is essential to provide adequate prevention.

Keywords: beach handball, injury, European championship

Introduction

Team handball is one of the most popular team sports worldwide, particularly in Europe, with increasing interest for sports physicians and orthopaedic surgeons [13]. Injuries in team handball are common and hence well published in the literature but little evidence exists about the injury characteristics in new developed and increasing trend sport beach handball [2, 11].

Following the introduction of the official rules in Beach Handball (BH) in the year 2002, the sport has gained popularity worldwide (Table 1). Beside national and international championships in BH, leagues have been developed in different nations. However, little is known about the frequency and severity of injuries during beach handball matches and scientific standardized injury statistics are lacking. The aim of this study was to describe for the first time the incidence and pattern of injuries in beach handball during the 10th senior and the 6th junior, both male and female, European Beach Handball Championships in 2017.

Table 1: Rules of beach handball in comparison to indoor team handball

	Beach handball	Team handball
Ball weight (g)	350-370 (280-300)	425-475 (325-375)
Ball circumference (female and u-17)(cm)	54-56 (50-52)	58-60 (54-56)
Court dimensions (m)	27 x 12	40 x 20
Surface	Sand, at least 40cm deep[1]	Parquet (wooden floor) or artificial floor
Goal dimensions (cm)	300 x 200	300 x 200
Players per team	4	7
Substitute players	6	7
Substitution (u-17)	Unlimited (unlimited)	Unlimited (only in ball possession)
Match duration (u-17)	2 periods of 10 (10) minutes	2 periods of 30 (25) minutes

[1]according to official rules of Fédération Internationale de Volleyball (FIVB)[4]

Methods

Team doctors and physiotherapists of all teams (n=56) were invited to participate in the study. All players of both sexes registered for the tournament were eligible for the study. Players were asked to submit a standardized baseline questionnaire which included age, height, weight, experience in team handball and beach handball, and past medical history. Informed written consent was obtained from all study participants and from the parents of the u-17 players, respectively.

Injury definition and data assessment

A newly occurred injury during the BH championships was defined as any musculoskeletal overuse complaint and/or traumatic injury occurred in competition during the tournament that received medical attention, regardless of the consequences with respect to absence from competition [5].

Time-loss injuries were graded into 5 categories of severity, i.e. minimal (absence from team handball of 0 days), slight (1-3 days), mild (4-7 days), moderate (8-28), and severe (>28 days) [5, 6]. Recurrent injuries (injuries of the same location and type) were only counted if the athlete had returned to full participation after the previous injury. An injury was categorized as overuse injury if no traumatic injury mechanism could be identified. Contact was defined as any contact between players or other object, such as the ball. Injuries due to contact with the sand were registered as non-contact injuries.

Injury reports and follow-up

Team doctors and physiotherapists of all participating teams were contacted within two weeks after the championships to report all new match injuries that have occurred during the tournaments and about the consequences of these injuries. If necessary, contact was repeated within 6 weeks. The number of days that had elapsed from the injury date to the date of full participation in BH or team handball were recorded as injury severity [5]. Team handball was included because all players were originally recruited from this sport.

Match exposure time

Each participating team had 10 accredited players. Unlimited substitution for all players during matches is possible and constantly used between defense and offense (table 1). There is no official record of playing time for each player. Player hours were therefore calculated for each team throughout the four championships by multiplication of the match duration of 20 minutes and the number of players on the court at the same time, i.e 4 players per team, with substraction of missed time due to suspensions and disqualifications. Exposure was calculated for each of the five player positions based on the most common team player formation with 2 wing players, 1 central defender, and 1 goalkeeper for defense and 2 wing players, 1 pivot, and 1 specialist for offense.

Statistics

Continuous data are expressed as mean and standard deviation (SD), and categorical data as frequency counts (percentages). Incidence rates of overall injury and time-loss injuries were calculated by dividing the number of events by total match exposure time in 1000 player-hours. Incidence rates were compared by use of an exact test based on the Poisson distribution. As effect estimates odds ratios and rate ratios accompanied by the corresponding 95 % confidence interval (CI) are reported. The significance level was set to $p < 0.05$, high significance to $p < 0.01$. All analyses were performed using IBM SPSS Statistics, version 24.0.

Results

300 players of 30 teams of 16 different nations were included in this study. Injury data of 100 senior players (40 male, 60 female) and 200 u-17 players (120 male, 80 female) were evaluated. 260 (46.4%) players were excluded from this study because they refused to participate or were lost to follow up.

30 teams participated each in a total of 238 matches. Each of the 20 junior teams played 7.1 ± 0.6 matches in 3 tournament days and each of the 10 senior teams played 11.1 ± 1.6 matches in 5 tournament days.

Injury pattern and injury mechanism

77 (26%) of the 300 players sustained 87 injuries resulting in an overall injury incidence of 286.1 injuries per 1000 h beach handball exposure. 15 (17.2%) injuries were time-loss injuries which results in an injury incidence of 49.3 per 1000 match hours. 8 players had 2 injuries and 2 players had 3 injuries during the tournament (Fig. 1).

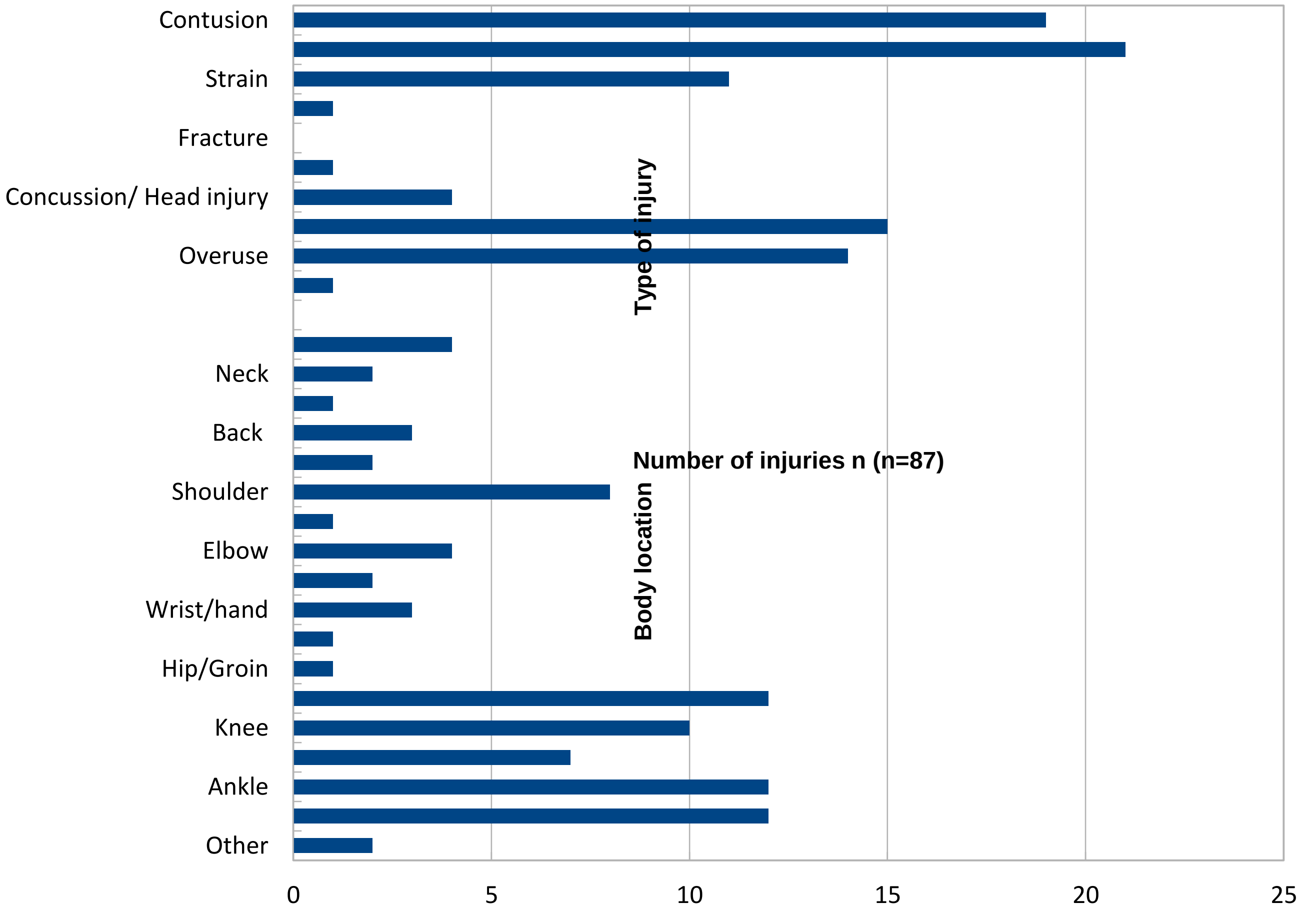

Fig. 1 Type of injury and body location

The most frequent injury type was sprain (24.1%), followed by contusion (21.8%) and skin lesion (17.2%). 3 injuries resulted in absence from beach handball for more than 3 days (3.4%)(Fig. 2). Ankle sprain (n=10), thigh contusion (n=8), and foot/toe skin injury (n=8) were the three most frequent specific diagnoses.

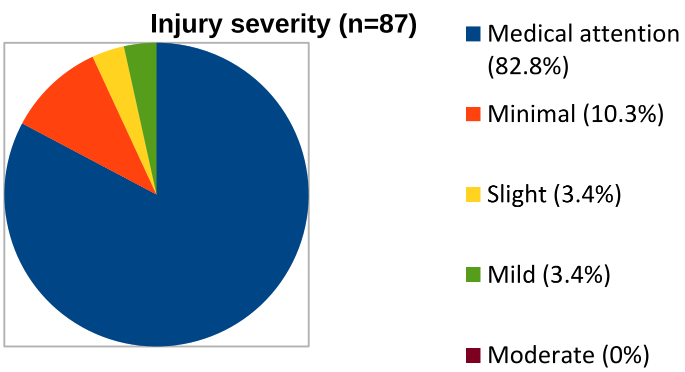

Fig. 2 Medical attention and time-loss injuries

63.2% (n=55) of all injuries were reported as the result of a non-contact mechanism. 16.1% (n=14) were overuse injuries. The thigh was the body region most affected by contact injuries (66.7%), while ankle (83.3%) and foot/toe (75%) were most affected by non-contact injuries. 86.7% of all skin injuries were due to contact with the sand.

Gender and age differences

Senior players had a higher injury incidence with 395.3 injuries per 1000 h match hours compared to the u-17 players with 205.7 injuries per 1000 h match hours (OR 0.29, 95% CI 0.17 – 0.50, $p<0.01$). The comparison of the injury incidence between the two sexes showed 330.23 injuries per 1000 h handball exposure for male players and 234.9 injuries for female players (OR 0.76, 95% CI 0.45-1.28, n.s.).

Position profile

The highest injury incidence was found among central defenders and specialists (table 2). Wing players sustained most foot/toe injuries (75%). Goalkeepers and central defenders sustained each two head/face injuries. No other differences in injury pattern and injury causes were found between player positions.

Table 2: Position-specific injury characteristics

Player position	Total match injuries (n)	Time-loss match injuries (n)	Exposure player-hours (h)	Injury incidence per 1000h match hours	Time-loss injury incidence per 1000h match hours
Wing	45	9	152.0	296.1	59.2
Central defender	14	2	38.0	368.4	52.6
Pivot	8	1	38.0	210.5	26.3
Specialist	12	0	38.0	315.8	0
Goalkeeper	8	3	38.0	210.5	78.9
Total	87	15	304.0	286.1	49.3

Discussion

The most important finding of this study is the first described injury incidence and injury characteristics among players of beach handball. This study shows beach handball has a lower time-loss injury rate compared to indoor team handball in international tournaments with similar setting [2, 10].

The total number of injuries during these tournaments, the prevalence, and the injury rate for severe injuries were all lower compared to international indoor team handball championships [2, 11]. Beach handball appears in particular safer for players regarding joint injuries of the lower extremity, which may influence the mid-term and long-term results after injuries, e.g. quality of life and degeneration of joint surfaces with development of early osteoarthrtis [3 ,12].

One important reason for the lower total number of injuries and lower incidence of time-loss injuries of the lower extremity are slower movements with and without the ball on the field. In addition, the sand allows different jumping and landing techniques, whereas in indoor team handball with artificial floor or parquett, injury types such as joint sprains may occur more easily. Similar findings were also documented by other publications in beach sports [1, 14].

Skin injuries have been found mostly to the foot/toe. This is possibly related to the specific playing conditions of being barefoot on a sand surface, as has been shown in transitions from firm ground to sand in other team sports [1, 14, 15]. Shoes are not allowed in beach handball [7]. Therefore, elastic binding around the ankles and/or feet should be used for injury prevention and protection of the foot [8].

The number of overuse injuries was high with 16.1% (n=14), with consideration that the tournament took only 3 and 5 days for junior and senior players, respectively. This may represent a consequence form the deep sand in the court, which players have to overbear during the match. The vast majority of players have been recruited from indoor team handball with different running performances and this beach handball tournament may have represented a short-term change on players` body, which results in a short-term rise of physical load for the player, which is known as a prinicipal influencing factor for injuries [10].

The highest injury incidence was found among central defenders and specialists. Both positions defend and attack the central shooting area, which has the highest scoring chance compared to the two wing areas. Therefore, more match play takes places and players are probably more risk taking and thereby more prone to injury. Next to goalkeepers, the central defenders also sustained the only two head injuries for outfield players which can also be explained by the match characteristics of blocking central shots while shots from the wing position are more controlled and more precise (Fig. 1).

Beach handball shows a low rate of time-loss injuries and can therefore be recommended for team handball players as a good alternative and/or modification for the summer break, the holiday or other occasional events. With growing professionalism, a detailed scientific medical attendance of this development is preferable for sufficient organization of injury prevention and other medical issues.

This study has some limitations. Several teams and players had dropped out before the start of the study period. This high dropout rate is similar to other epidemiological studies in sports and related with the low compliance of participating players to the study design and missing experience with scientific studies [9, 10]. A calculation of the power was also not possible due to the limited number of participants in this study. This also had a consequence on the calculation of differences regarding age and gender. The strength of the study is the compilation of the medical data directly by the medical staff.

This epidemiological study about injury incidences and injury profiles in beach handball is an important fundament and future studies should be executed to provide more specific data about differences between age, gender, and other important topics. For the daily routine of the medical service in beach handball competitions, the injury profile and an adequate preparation to the most important injury types of this new sport have been presented.

Conclusion

This study showed for the first time a specific injury profile in the new developed trend sport beach handball as a sufficient alternative or addition to Europeans` number 2 sport of indoor team handball.

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THE HANDBALL 4 HEALTH PROJECT - PROMOTING TEAM HANDBALL AS A HEALTH AND FITNESS ENHANCING SPORT FOR ALL!

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Summary
Although physical activity (PA) and exercise are important in the prevention and treatment of cardiovascular and metabolic diseases, a third of the adults worldwide do not reach the recommended levels for daily PA. Recreational team handball practice is an accessible, high-adherence and high-attendance exercise mode with high physical and physiological demands, positively impacting on health and physical fitness of several populations.

Keywords: recreational team handball, health, physical fitness, physical and physiological demands.

Introduction

Physical activity (PA) and exercise are important in the prevention and treatment of cardiovascular and metabolic diseases. Yet, a third of the adults worldwide do not reach the recommended levels for daily PA (Hallal et al., 2012) and 20% of the European population report lack of motivation as one of the causes for not exercising or playing sport more frequently (European Commission, 2014). Thus, it is of paramount importance for public health to identify more exercise modes that can meet the PA guidelines, while keeping the participants motivated and assuring long-term adherence. Team handball is one of the most popular and widely practiced team sports worldwide. Thus, the Handball4Health project was developed with the aim to examine the physical and physiological demands of recreational team handball, to understand its effects on health and physical fitness and on reducing physical inactivity, and thus, the risk of developing lifestyle chronic diseases, in several populations. This, to promote and to disseminate team handball recreational practice as a health and physical fitness enhancing sport all over the world.
This project is a multidisciplinary, international, innovative intervention/research initiative supported by several research centers, universities and other entities, including the European, Portuguese and Danish Handball Federations.

Development

Competitive team handball is a high-demanding intermittent (600-1500 activity changes per match) exercise, that primarily uses the aerobic metabolism, interspersed by high-intensity actions that greatly tax the anaerobic pathway (post-match blood lactate of 3-11 mM) (Cardinale, Whiteley, Hosny, & Popovic, 2016; Karcher & Buchheit, 2014; Wagner, Finkenzeller, Wurth, & von Duvillard, 2014). Matches are performed at 65-80% and 80% of players' maximal oxygen uptake (VO_2max) and maximal heart rate (HRmax), respectively. Players spend ~70% of match time walking and jogging, covering 2600-4700 m per match. Team handball played at competitive level is a body contact sport that involves many high-intensity actions like jumps, shots and tackles related to one-on-one situations that result in high bone and muscle impact. Given the nature of team handball, the interest of the Handball4Health project was to ascertain whether the recreational version demands could result beneficial to improve and or maintain physical fitness and health in various populations. In the first study of the Handball4Health project, Póvoas el al. (2017) analyzed recreational team handball matches of sedentary men (inactive in the previous 13±7 years) with former experience (19±3 years, 2-7 training sessions per week) in competitive team handball. Fifteen 33-55 years-old men (13 outfield players and 2 goalkeepers) were evaluated during four 7v7 matches of 60-min each, interspersed by a 10-min half-break. No time-out periods were allowed unless for players' physical assistance (e.g., injuries). During the 60-min recreational team handball matches, the players covered 6012±428 m reporting 388±70 activity changes, of which 59±18 and 26±26 were high-intensity runs and unorthodox movements, respectively. Jumps and throws were the most frequent highly demanding playing actions. Players' average exercise HR was 82±6% of HRmax peaking at 93±5%HRmax. Interestingly, 24% (14±15 min) of total match time was spent at HR>90% HRmax. Match blood lactate concentrations were 3.6±1.3 and 4.2±1.2 mM, for average and peak values, respectively. PA guidelines per match in moderate-to-vigorous activity and in vigorous intensity were 27±7 (4-39)% and 10±9 (0-36)%, respectively. The encouraging evidence gained with the sedentary former team handball players study, suggested a training intervention to test the effectiveness of the considered exercise paradigm (60-min, 7v7) in inducing beneficial effects on health and physical fitness related variables. During 12 weeks, fifteen participants trained 2-3 times a week, for 60-min playing recreational team handball (THG), with a control group (CG; n=9) maintaining inactive per the intervention period. Pre-to-post-intervention evaluations reported significant time-by-group interactions for Yo-Yo intermittent endurance level 2 test (YYIE2) performance (p=0.015), VO_2peak (p=0.024), resting HR (p<0.001), resting blood glucose (p=0.052), HDL cholesterol (p=0.048) and postural balance (p=0.019) in favour of the THG. With a high training attendance of 2.2±0.7 sessions/week (26±9 sessions in total) the THG reported a marked 80% (p<0.001) increase in YYIE2 (360 to 673 m), a 27% (p=0.018) drop in the number of falls (16 to 11 falls), a 14% (p<0.001) increase in VO_2peak (39.6 to 44.5 mL/min/kg), a 16% (p<0.001) decrease in resting HR (62 to 52 bpm), a 11% increase (1.2 to 1.3 mmol/L) in HDL cholesterol (p=0.002) and a 7% (4.7 to 4.4 mmol/L) decrease in resting blood glucose (p=0.052).

The population effect of using recreational team handball as a training intervention was subsequently examined in two successive studies that focussed on young and postmenopausal women with little or no experience in the sport. In the postmenopausal women study, 35 participants (66.4±6.1 years; 158.0±6.3 cm; 65.6±10.0 kg and 38.0±10.2% fat mass), with no previous experience in the sport, were randomly assigned to an intervention (THG; n=20) and a control group (CG; n=15) (Póvoas et al., 2017). After 16 weeks of 2-3 per week 60-min team handball small-sided games sessions, the THG improved their VO_2max by 9% (25.2±3.5 vs. 27.2±3.5 mL/min/kg; p=0.01) and their YYIE1 performance by 93% (from 238±84 to 461±249m; p<0.001). Significant changes in body mass (65.5±10.9 vs. 64.3±10.1 kg; p=0.03), lumbar spine (+1.6%) and hip neck (+2.1) bone mineral density (BMD; p=0.01) were found only in the THG. Mean and peak match HRs were 78±5% and 88±4% of HRmax, respectively, with HRs being >80%HRmax for 49±23% of total match duration. Rate of perceived exertion was 5.6±1.8 (AU, 0-10).

After playing recreational team handball for 12 weeks (70 min, 4v4 handball sessions) for an average of 1.7±0.3 time per week, a group (THG) of 20-30 years-old inactive women (n=14; stature 170±5 cm; body mass 73±11 kg and VO_2peak 37.7±4.1 mL/min/kg) significantly improved muscle mass (2.1%, p=0.024) and proximal femur BMD (0.8%, p=0.041) (Hornstrup et al., 2017). The THG significantly improved YYIE1 performance (+35%; p<0.001) and treadmill time to exhaustion (+11.5%, p=0.003). In the control group (n=14; 169±5 cm; 71±12 kg and 38.1±3.7 mL/min/kg^{-1}), no changes were observed in any of the measured physiological variables after the 12 weeks in which they continued with their daily physical activity routine. Compared to the control group, the THG had an increase in intrinsic motivation (p<0.001) and in the well-being subscale "energy" (p=0.010).

Conclusions

Results from training studies have shown that recreational team handball is an accessible, high-adherence and high-attendance exercise mode, with physiological demands in the range of those found to have a positive effect on aerobic, anaerobic, and musculoskeletal fitness in sedentary adults. Recreational team handball practice has shown to provide a high aerobic component (HRs~80%HRmax) associated with multiple actions performed at high intensity, demands that stress the anaerobic metabolism and have a high impact on the musculoskeletal system. Given the encouraging remarkable positive effects of team handball recreational practice on health, physical fitness and wellness variables, the main aims of the Handball4Health project are to further develop the current knowledge on its effects on other participants and to promote recreational team handball in other countries. As a result, novel studies assessing the effects of recreational team handball-based programmes on physical fitness and health of several populations as a way of preventing the development of lifestyle diseases are warranted.

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IMPROVING AGILITY PARAMETERS IN YOUNG HANDBALL PLAYERS

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Summary
Agilty is the ability to explosively stop, change direction, and accelerate again. Agility is interrelated with speed and quickness in sports activities. These elements are very important in many games, such as football, basketball and certainly, in our sport-handball. Most team sports are characterized by rapid accelerantion, change direction, explosive stop, on small distances (5-10-15 metres).

Keywords: agility, speed, stimulus, body control, proprioceptions, handball

Introduction
One definition by some researches for agility is ´´a rapid whole body movement with change direction in responses to a stimulus´´. In handball one has quickly to respond to the position of the ball and the movement of the other players. In order to be agile, a player has to respond to a stimulus or what happens around them, taking the information and translating it into a body positioning that will maintain balance and body control.

- Speed

A player, who is more speedy than their opponent, is clearly at an advantage. For example, a player who can move fast and can take the ball faster is better than the other player. To this end, teams lay the stress on this qualitiy of the player. Throughout a match, a player seldom runs 30 or 40 metres in a straight line, thus it is not necessary to develop such ability. However, unidirectional speed is very important to develop in all the players as a player has to change direction all through a match. In conclusion it is more important to alternately accelerate and stop, not to keep running long distances

Proprioceptors
Proprioceptors are sensors that provide information about join angle, muscle length and muscle tension, which give the brain information about the position of the limbs in space at any given time. Because proprioceptive signal from the joints, muscle, tendon and skin are esential for movement, the loss of proprioceptive awareness affect the control of muscle tone, disrupt reflex and severely impair voluntary movement. Numerous neurological and orthopedic factors are associated with proprioceptive and kinesthetic impairment such as some diseases and in sports life, injuries to ligaments, joint capsule and muscle. For that purpose proprioception training could be benefical to anyone that has been affected. Athlets, eldery, children those afflicted with neurological or orthopedic condition may benefit from proprioception improvement.

Proprioception refers to the ability of the body to feel movement within joints and joint position. This ability enables us to know where our limbs are in space without having to look at them as this is important in complicated sporting movements within which precise coordination is essential.

For that reason we must show the importance of muscular condition. We have a nervous system of receptors (proprioceptors) located in muscles, joints and ligaments. These receptors can sense changes similar to the way other receptors monitor our body(sound, preassure, heat..) and send signals to the brain. Then the brain sends a message to the muscle telling them what to do. The hamstring muscles are very important like a multi-articular muscle group because they cross on hip and knee and are responsible to slow the lower parts (feet), furthermore, they help to hip extension getting prepared for propelling the sprint.

The Abductor muscles(gluteus maximus, gluteus medius, tensor fasciae latae) are responsible for lateral movement. For example, changing direction as fast as possible when the player makes some tricks. So, it is important to pay attention to this group of muscles because they can influence agility.

The quadriceps femoris is a large group ofmuscles and they are subdivided into four separate portions of heads´ (rectus femoris, vastus lateralis, vastus medialis, vastus intermedius). All the four quadriceps are powerful extensors of the knee joint. They are crucial in walking, running and jumping. In straight training the quadriceps are trained by several leg exercises.

Methods

Subjects

In this study we want to show how agility cap be improved by some exercises with cones, elevated surface exercises, relays games and dynamic games with and without ball.We have used three methods:

1. Test method
2. Grafic representation method
3. The statistical-mathematical method

We tested 8 girls of ages between 13-14 from our club, Golden Kids Bacau, and 8 girls from an ordinary school of the same age to see the difference between the two groups: those who took exercise for agility and those who didn´t take exercise.

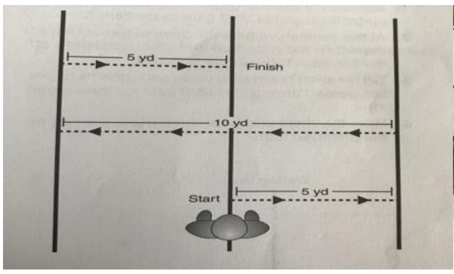
Testing procedure

- Pro agility test

Purpose: To test multidirectional speed, agility, and body control.

Procedure:

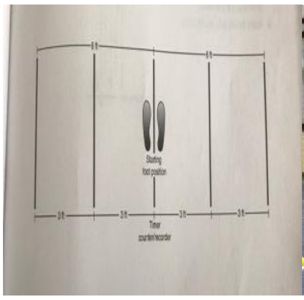
1. Have the player start in a two-point stance stradling the straddling line.
2. Instruct the player on the ´Go´command to turn and sprint to the right, touching the line (4,6 m) away with the right hand.
3. Have the player then turn to the left, sprin (9.1m), and touch the far line with the left hand.
4. Have the player then turn back to the right and sprint (4.6 m) through the start/finish line, and stop the clock.
5. Use the disqualification criterion of not touching line with alternate hand.



- Edgreen Side Step

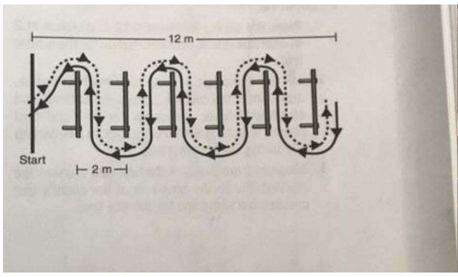
Purpose: To test lateral speed, agility, and body control.

Procedure:
1. Have the player stand in a two point stance, stradling the center line.
2. Instruct the player to sidestep to the right until his or her right foot has touched or crossed the right outside line.
3. Instruct the player to sidestep to the left until his or her foot has touched or cross the left outside line.
4. Have the player continue to sidestep back and forth to the outside lines as rapidly as possible for 10 s.
5. Ensure that the player faces forword and side shuffles for the entire test.
6. Each completion of a 0.9 m increment(from center line to the first increment, from the first increment to outised line back to firs incremenet,)counts as 1 point.




- Slalom test

Purpose: To test multidirectional speed, agility, and body control.
Procedure:
1. Place six hurdles over a 12 m distance at 2 m intervals.
2. Instruct the player to run at maximum speed in a slalom pattern between the hurdles, both forward and backward to the starting point.
3. Measure from the time the first foot crosses the starting line to the time one of the feet crosses the same line for the last time.



Each test was selected from „Functional Testing in Human Performance” book (Author’s Michel P. Reisman and Robert C. Manske)

Exercises meant for improving agility
<u>Exercise 1</u>
Lateral pylometric jump- help buid dynamic power, coordontion and balance. This exercises is a must for any sportsman who needs lateral power and coordination
<u>Exercise 2</u>
Speed ladder agility drills - forward running, high knee drill for improving foot speed and coordination for lateral running.
<u>Exercise 3</u>
Dot drill- progress to one foot hopping and follow a specific jump pattern

Exercise 4

Plyometric box jump drills – are great to build explosive power and foot speed (for this age a small box is recommended. And keep back flat to prevent injury

Exercise 5

Sprint training –to develop foot speed and agility for explosive speed and quickness

Set up two markers about 15 m apart and sprint forward from the first cone to the far cone. Stop at the far cone and jog or run backwords to the start. (repeat this 10 times)

Exercise 6

Plyometric agility hurdles- to build power and speed, improve coordination and agility(using a set of small hurdles for bouting on one or both feet can improve agility. Start with jumping upward and forward to clear each hurdle landing lightly on the balls of the feet.

Repeat the drill on only the right foot and then only one the left foot.

Exercise 7

Shutlle runs – is a standard agility and speed drill

Set up a source with two markers about 10-15 metres. Sprint from one marker to the other and back. That is one repetion. There is a variety of different ways to do shuttle run, including side to side runs, forward and backward runs etc.

Exercise 8

Agility balls - use a small agility ball and bounce it to a partner. Because the agility ball shape will send the ball in varying direction, use a safe space. Practise catching the ball with the hands, first with your dominate hand and after that with your non-dominate hand. Hand-eye coordination activities help increase mental stimulation and chasing this tiny tool around is great for the heart and legs.

Exercise 9

Cone Drills – Set two cones up . The distance from one to other cone is 6 meters. Lateral running until the signal (whistle) then run 15 metres at maximum speed and back to start again.

Exercise 10

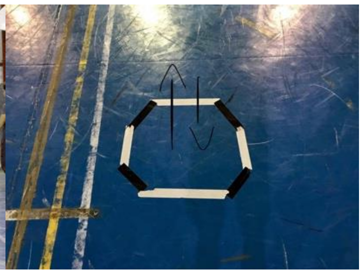
Make a hexagon on the floor whith colored stripes. A player must jump from the centre of the hexagon over the all sides. These exercises improve lateral movement for defense players, specially. Repeat 10 times .

Exercise 11

While looking at the floor, raise and extend your right arm and your left leg at the same time. Keep a tight core. Hold for 4-5 seconds and repeat on the other side. Do 10 reps on each side.

More difficult: hold 20 seconds with eyes closed. Focus on a tight core and perfect balance keeping the arm and leg parallel to the floor.






Results

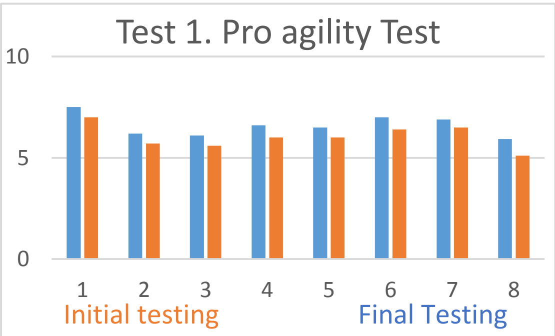
Table 1. The results of the tests –group that used agility exercises

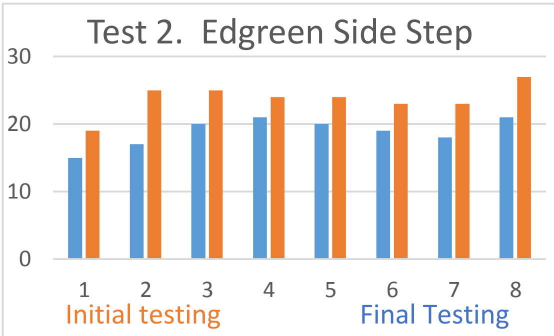
Golden Kids Club Bacau						
Age	Test 1. Pro agility test		Test 2. Edgreen Side Step test		Test 3. Slalom test	
	Initial testing (seconds)	Final testing	Initial testing (points)	Final testing	Initial testing (seconds)	Final testing
	7,5	7	15	19	10,6	9
	6,8	6,5	18	23	10	9,7
	5,9	5,1	21	27	8,9	8
	6,2	5,7	17	25	9,7	8,5
	6,1	5,6	20	25	10,7	9
	6,6	6	21	24	10,5	9,2
	6,5	6	20	24	10,3	9,1
	7	6,4	19	23	13	11,2

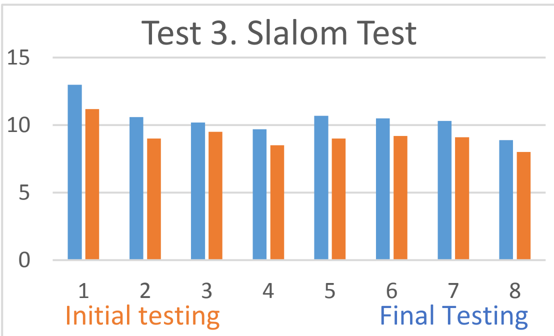
Table 2. The results of the tests – group that did not used agility exercises

Ordinary school (Group who don´t applied agility exercises)						
Age	Test 1. Pro agility test		Test 2. Edgreen Side Step test		Test 3. Slalom test	
	Initial testing (seconds)	Final testing	Initial testing (points)	Final testing	Initial testing (seconds)	Final testing
	8	7,8	13	14	15	14
	7,9	7,5	15	16	14	11,5
	7,7	7,5	13	14	13	12,4
	8,2	8	16	17	13	12,5
	8,9	8,7	17	19	11	10,6
	7,5	7,4	15	18	12,4	12
	8	7,9	12	15	12,1	11,3
	9,	8,7	15	17	14	13,2

Graphis of results Golden Kids Club Bacau







Conclusions

The cortex is plastic and motor skills are very rapidly capted but the same time very rapidly lost. Repetion is recomended.

Agility can be develov if throughtout the lessons/trainnings similar exercises are used meant to challange fund of the childran regarding the ways of in wich speed manifest.

We recomended that ths set of exercises should be introduced in trainnings. Starting with the age of 10, as at his age coordination can be very well influenced, like agility skills.

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STUDY ON INFLUENCING THE STATIC BALANCE THROUGH THE USE OF PROPRIOCEPTIVE MEANS

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This study set out to evaluate the displacement of the centre of gravity using the bipodal balance test with eyes open and closed, aided by AMTI's BP400600 force platform, taking into account the average displacement value along the X axis.
The sample we have worked on were women's handball players of the 6 m line (centers and wingers), divided into two groups (experimental and control) of 10 athletes each.
The results obtained during this study have confirmed that static balance parametres can be significantly improved by using proprioceptive methods.

Keywords: handball, proprioception, static balance.

Introduction

Postural control or balance is defined as the ability to maintain a support base with minimal movement, as well as the ability to perform a task meanwhile maintaining a stable position. It is maintained with the dynamic integration of internal and external forces and factors involving the environment (Lee, A. et.al., 2006, pp. 117–125; Bressel, E. et.al.., 2007, pp. 42–46). Adjustment of balance depends on visual, vestibular and proprioceptive stimuli (Subasi, S.S., et.al., 2008, pp. 186–205; Gribble, P.A., et.al., 2007, pp. 35–41).
Barati, A., et.al., (2013, pp. 289-294); Bressel, E.,et.al., (2007, pp. 42-46) define static balance as „an ability of the body to maintain its centre of gravity within its support base".
Authors Freiwald, J., et.al., (2006, pp. 140-150) and Gstöttner, M., et.al., (2009, pp. 218-231) stress the importance of developing balance relying on scientific co-ordination training programs to prevent injuries and improve performance.
It is recommended that young athletes, in order to train balance, begin with exercises focusing on static balance and proceed only later to more complex exercises aimed at dynamic balance.
Balance training is recommended to start on a stable surface with a broad support base and visual feedback. To increase efficiency the difficulty of execution should be raised: narrow support base with eyes open; broad support base with eyes closed; narrow support base with eyes closed.
One current trend is to introduce specific elements of proprioceptive development into the structure of training programs, designed to improve the specific parametres of static and dynamic balance as well as neuromuscular coordination, starting from an early age (Acsinte, A., et.al., 2012, pp. 28-32).

Materials and methods

The study was conducted during a season. Two groups of athletes were involved (experimental and control group), each consisting of 10 youth players of U17, all 6 m line players (wingers and centers).
We applied the bipodal balance test with eyes open and eyes closed on the subjects, using AMTI's BP400600 force platform (for 15 seconds), taking into account the mean displacement value along the X axis.
Both groups trained according to the same training plan. However, the experimental group underwent a 30-minute training using proprioceptive methods three times a week, with the purpose of optimising static balance.
The proprioceptive methods used during the training program are presented below. Balance fits, elastic bands, handball balls were used as follows: passing in pairs (threes) with both hands above head, standing on parallel balance fits; same exercise passing the ball with both hands from chest; same exercise passing with one hand above shoulder; same exercise with foot opposing passing

hand in front; passing in pairs (threes) with one hand above shoulder, balancing on foot opposing passing hand; same exercise with balancing on foot on passing hand's side; while walking forward on 10 lined up balance fits, catching and passing the ball diagonally, left-right. In order to disturb balance, place an elastic band on hip and pulling backwards, left and right. To further increase difficulty, catching and passing the ball can be made while standing on one foot.

Results and discussion

Bipodal balance with legs close together, eyes open – experimental group

The average displacement along the X axis registered by athletes at the bipodal balance test with legs close together, eyes open, conducted to evaluate static balance, decreased after the end of the training period by 0.345 (57.6%), from 0.599 to 0.254 cm. This decrease represent an improvement in static balance. In both test the dispersion of data is uneven (**Tables 1 and 2**).

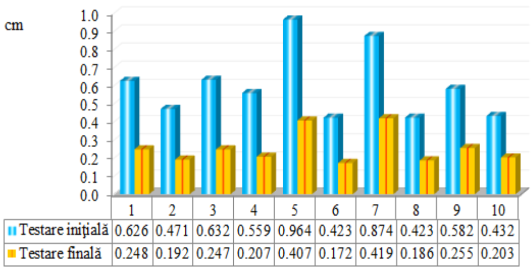
Table 1. Values of initial and final testing for experimental and control group

	EXPERIMENTAL GROUP		CONTROL GROUP	
Nr.	Initial testing (cm)	Final testing (cm)	Initial testing (cm)	Final testing (cm)
1.	0,626	0,248	0,414	0,379
2.	0,471	0,192	0,364	0,302
3.	0,632	0,247	0,304	0,324
4.	0,559	0,207	0,419	0,368
5.	0,964	0,407	0,409	0,325
6.	0,423	0,172	0,344	0,274
7.	0,874	0,419	0,384	0,327
8.	0,423	0,186	0,330	0,277
9.	0,582	0,255	0,352	0,296
10.	0,432	0,203	0,388	0,317

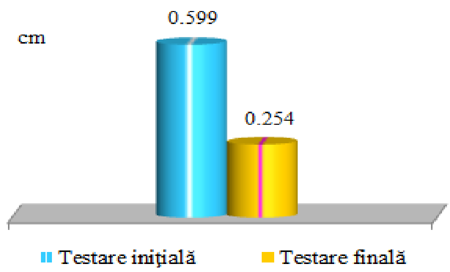
Table 2. Statistical analysis before and after conducting the training program – experimental group

Testing	Average	Avg. Diff.	Median	Min.	Max.	Coeff. of variation	WILCOXON TEST		Effect size
							Z	P	
Initial	0.599	-0.345	0.571	0.423	0.964	31.4%	-2.803	0.005	0.63
Final	0.254	57.6%	0.227	0.172	0.419	35.0%			

The decrease in displacement is statistically significant according to the Wilcoxon test, with z = -2.803 and p = 0.005 < 0.05. The effect size (0.63) shows a large to very large difference between the two testings. **Graphs 1** and **2** show the individual displacement distances and the averages of the two testings for the experimental group.



Graph 1. Bipodal balance with legs close together, eyes open, experimental group



Graph 2. Initial and final testing inital values –experimental group

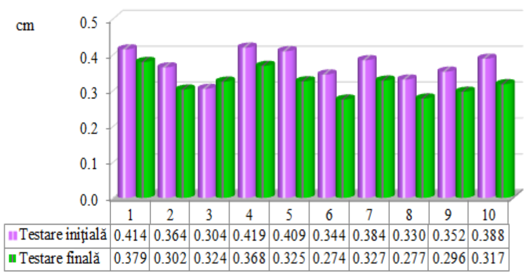
Bipodal balance with legs close together, eyes open - control group

The average displacement value along the X axis, produced at the bipodal balance testing with legs close together, eyes open, for the evaluation of static balance, decreased at the final testing by 0.052 (14.0%), from 0.371 to 0.319 cm. In both test the dispersion of data is even (**Tables 1** and **3**).

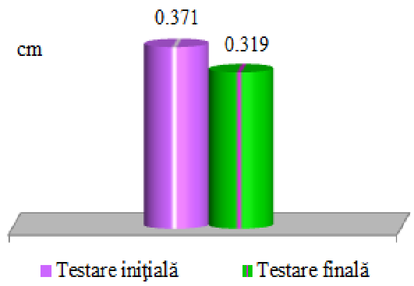
Table 3. Analysis of statistical-mathematical indices – control group

Testing	Average	Avg. Diff.	Median	Min.	Max.	Coeff. of variation	WILCOXON TEST		Effect size
							Z	P	
Initial	0.371	-0.052	0.374	0.304	0.419	10.4%	-2.701	0.007	0.60
Final	0.319	14.0%	0.321	0.274	0.379	10.8%			

The Wilcoxon signed-rank test, with z = -2.701 and p = 0.007 < 0.05, shows a statistically significant decrease in displacement. The effect size index (0.60) shows a large to very large difference between the two testings. **Graphs 3** and **4** show the individual displacement distances recorded during this test, and the averages of the two testings for the control group.



Graph 3. Bipodal balance with legs close together, eyes open – control group



Graph 4. Initial and final testing average values –control group

Control vs. Experimental after conducting the training program

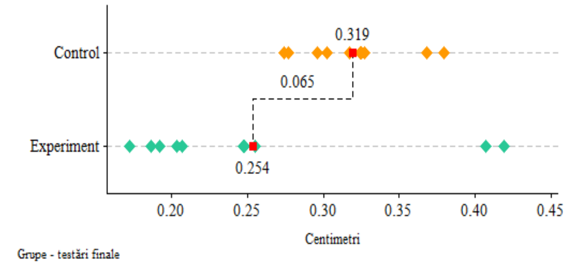
Bipodal balance with legs close together, eyes open

When testing bipodal balance with legs close together, eyes open, a smaller average value of displacement along the X axis was found for the experimental group by 0.065 (20.5%). This difference shows an increase in static balance with the experimental group. The average of the experimental group is 0.254, while that of the control group is 0.319 cm. The dispersion of data is uneven for the experimental group and even for the control group (**Table 4**).

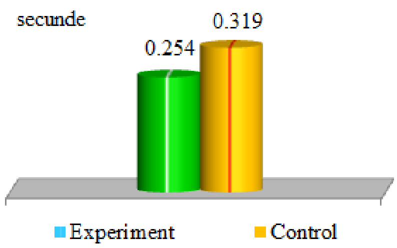
Table 4. Comparative statistical analysis of control vs experimental groups – bipodal balance with legs close together, eyes open

Grupe	Average	Avg. Diff.	Median	Min.	Max.	Coeff. of variation	Mann-Whitney		Effect size
							Z	P	
Experimental	0.254	-0.065	0.227	0.172	0.419	35.0%	-2.268	0.023	0.51
Control	0.319	20.5%	0.321	0.274	0.379	10.8%			

The difference is statistically significant according to the Mann-Whitney significance test, with z = -2.268, p = 0.023 < 0.05. The effect size index (0.51) shows a large to very large difference between the two groups. The individual displacements and the final testing averages corresponding to the two groups are presented in **Graphs 5** and **6**.



Graph 5. Graphical **r**epresentation of the results of the two groups –bipodal balance with legs close together, eyes open



Graph 6. Average values experimental – control group

Bipodal balance with legs close together, eyes closed – experimental group

The average displacement along the X axis measured duringthe bipodal balance test with legs close together, eyes closed, for the evaluation of static balance, decreased by the end of the training period by 0.250 (45.5%), from 0.549 to 0.299 cm. The dispersion of data is uneven at the initial testing and relatively even at the final one (**Tables 5** and **6**).

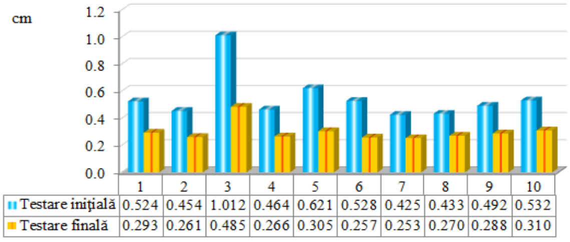
Table 5. Values of initial and final testing for experimental and control group

	EXPERIMENTAL GROUP		**CONTROL GROUP**	
Nr.	**Initial testing (cm)**	**Final testing (cm)**	**Initial testing (cm)**	**Final testing (cm)**
1.	0,524	0,293	0,510	0,455
2.	0,454	0,261	0,485	0,388
3.	1,012	0,485	0,407	0,375
4.	0,464	0,266	0,420	0,356
5.	0,621	0,305	0,603	0,532
6.	0.528	0,257	0,563	0,433
7.	0,425	0,253	0,593	0,492
8.	0,433	0,270	0,5,15	0,485
9.	0,492	0,288	0,576	0,464
10.	0,532	0,310	0,483	0,454

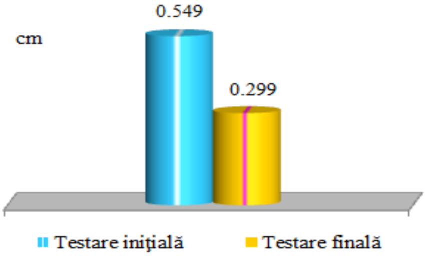
Table 6. Analysis of statistical-mathematical indices– experimental group

Testing	Average	Avg. Diff.	Median	Min.	Max.	Coeff. of variation	WILCOXON TEST		Effect size
							Z	P	
Initial	0.549	-0.250	0.508	0.425	1.012	31.5%	-2.803	0.005	0.63
Final	0.299	45.5%	0.279	0.253	0.485	22.9%			

The decrease is statistically significant according to the Wilcoxon significance test, with z = -2.803 and p = 0.005 < 0.05. It also highlights a significant improvement in static balance. The effect size (0.63) shows a large to very large difference between the two testings. **Graphs 7** and **8** show individual displacements and the averages of the two testings of the experimental group.



Graph 7. Bipodal balance with legs close together, eyes closed – experimental group



Graph 8. Initial and final testing average values – experimental group

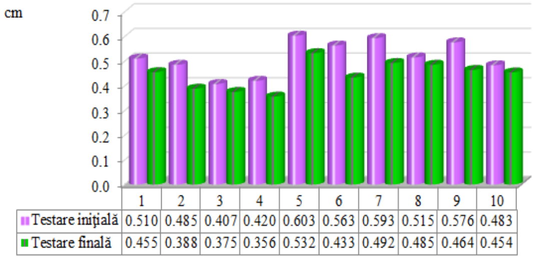
Bipodal balance with legs close together, eyes closed – control group

The average distance along the X axis recorded by athletes at the bipodal balance test with legs close together, eyes closed, for the evaluation of static balance, decreased at the final testing by 0.072 (14.0%) cm, from 0.516 cm to 0.443 cm. The dispersion of data for both tests was even (**Tables 5** and **7**).

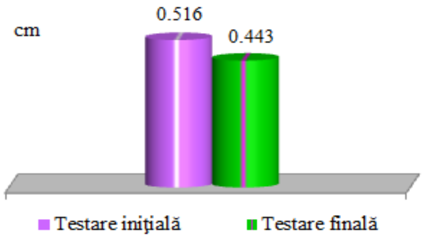
Table 7. Analysis of statistical-mathematical indices – control group

Testing	Average	Avg. Diff.	Median	Min.	Max.	Coeff. of variation	WILCOXON TEST		Effect size
							Z	P	
Initial	0.516	-0.072	0.513	0.407	0.603	13.3%	-2.803	0.005	0.63
Final	0.443	14.0%	0.455	0.356	0.532	12.6%			

The decrease is statistically significant according to the Wilcoxon significance test, with z = -2.803 and p = 0.005 < 0.05. The effect size index (0.63) shows a large to very large difference between the two testings. G**raphs 9** and **10** show the distances and their averages at both testings of the control group.



Graph 9. Bipodal balance with legs close togeth, eyes closed - control group



Graph 10. Initial and final testing average inițială values –control group

Control vs. Experimental after conducting the training program

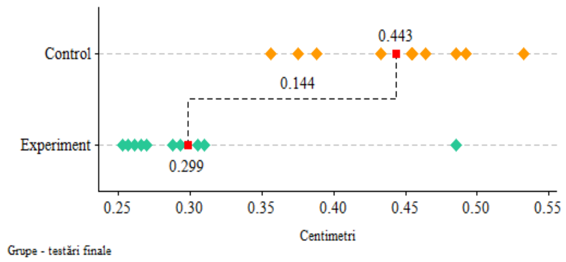
Bipodal balance with legs close together, eyes closed

The bipodal balance test with legs close together, eyes closed, showed a smaller mean displacement of the experimental group by 0.144 (32.6%) cm. This means a better static balance of the experimental group. The averages are 0.299 for the experimental group and 0.443 cm for the control group. The dispersion of data around the average is relatively even for the experimental group and even for the control group (**Table 8**).

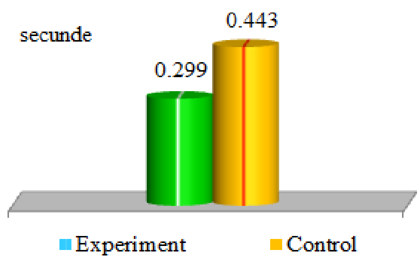
Table 8. Comparative statistical analysis - experimental vs control group – bipodal balance with legs close together, eyes closed

Grupe	Average	Avg. Diff.	Median	Min.	Max.	Coeff. of variation	Mann-Whitney		Effect size
							Z	P	
Experimental	0.299	-0.144	0.279	0.253	0.485	22.9%	-3.214	0.001	0.72
Control	0.443	32.6%	0.455	0.356	0.532	12.6%			

The difference between the two averages is statistically significant according to the Mann-Whitney significance test, with z = -3.214 and p = 0.001 < 0.05. The effect size index (0.72) shows a large to very large difference between the two final testings. The displacement distances and their averages corresponding to the two groups at the final testings are presented in **Graphs 11** and **12**.



Graph 11. Graphical representation of the results of the two groups – bipodal balance with legs close together, eyes closed



Graph 12. Experimental group - control group average values

Conclusions

The complexity of movements involved as well as the exercises on different surfaces (sand, lawn, various devices, etc) lead to facilitating the balance training process. Unstable surfaces have the role of increasing muscle activity to the detriment of mechanical load. By introducing unstable surfaces, proprioceptive feedback is uncertain because the control mechanism responsible for maintaining balance is permanently stimulated, making it difficult to maintain posture.

Careful follow-up and periodic evaluation of static balance in young handball players is an important parametrein order to correctly design and modify training programs, which would allow the development, improvement and maximizing of a wide range of fundamental motor abilities, depending on the age of the athletes.

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REHABILITATION, PREVENTION AND PHYSICAL TRAINING BY MEANS OF BEACH HANDBALL EXERCISES

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Summary
Beach handball exercises have proved to be useful for rehabilitation, prevention and alternative physical training for team handball players. Compared to training on harder and faster surfaces, such as an indoor court, the muscles, tendons and joints of the lower extremities are challenged physiological differently when moving in sand due to the soft and unstable surface that sand create. Training in soft dry sand challenges the balance and coordination of team handball players. Thus, training in sand can help create a larger movement repertoire for players, which ultimately may help to reduce the risk of injuries. This article gives examples of beach handball exercises that can be used in rehabilitation, prevention and as alternative physical training for team handball players.

Keywords: Beach handball, low impact, coordination, rehabilitation, prevention training,

Beach handball

Beach handball has emerged as a new worldwide, popular discipline, but is still regarded as an alternative and casual game. Beach handball was created with specific rules to be more spectacular than indoor team handball. However, many top elite players have been prohibited from taking part in the beach handball tournaments due to the fear of possible injuries especially on the lower extremities. Therefore, information is needed to explain the potential risks, training and playing in sand may have on team handball players. In contrast, it is also interesting to know if beach handball exercises performed in the sand can be used in rehabilitation and as an alternative prevention and physical training to improve the physical performance in team handball.
In general, studies of beach handball are very limited. Thus, knowledge regarding the effect of beach handball training and match-play is still to a considerable extent relying on accumulated experience. Information from major beach handball tournaments during the past decade does not reveal more injuries compared to indoor team handball tournaments at similar levels of competition. In fact, beach handball may even be safer than the indoor game due its playing surface and the different rules, according to the preliminary results from an analysis of the 2017 EHF European Beach Handball Championships. This article presents and discusses examples of programs using beach handball exercises for rehabilitation, prevention and alternative physical training for team handball players engaged in normal, indoor competitive matches and tournaments. However, players competing in beach handball may also benefit from the present training programs.

Sand

The amount of energy needed when moving in sand is different depending on the characteristics of sand. Surface properties such as granulation, moisture content and/or depth contribute to the rigidity of the sand. Studies have measured the maximum deceleration force in soft dry beach sand to around 225 N compared to 900 N on grass (Pinnington & Dawson, 2001a, 2001b). The peak deceleration forces in wet beach sand is determined to be around 850 N. These measurements show that training in sand may differ according the structure of the sand, which must be taking into account when using sand as a surface for alternative physical training. The deceleration forces in dry beach sand compared to wet beach sand will have a decisive influence on what kind of training is the best to perform in the different types of sand.

Soft sand as a rehabilitation and injury prevention training surface

Soft, dry beach sand has high absorptive qualities as seen in the peak deceleration force. Thus, much of the energy produced by the muscles will be absorbed when running and jumping in the sand, resulting in a reduction of the ground reaction force compared to the indoor court. Experience shows that beach handball training can be useful in rehabilitation of the players, as there will most likely be a smaller risk of new injuries when training in soft sand with a lower impact, e.g. a significant less probability of a twist in the ankle. In addition, soft sand can also act as an injury prevention training surface, as the muscle activating strategies needed to create balance are challenged to the limit. Consequently, the effect of well-known prevention training strategies will probably be enhanced when training on sand surface.

Beach handball exercises that focus on rehabilitation and prevention training

Walking and running

Start walking in sand and let the players feel the sand between their toes, which is a good start when training sensory motor skills. Then start running at low speed, start forward, then progresses with variations (backwards and sideways) run with low speed in max. 30-sec intervals focusing on balance and running quality. Progression of the exercises depends on the players' state of rehabilitation. The aim is to utilize the unstable basis to challenge the lower extremities when it comes to the postural control.

Exercises in relation to balance

When training balance, it is all about quality. The exercises must be performed in the start of the training session when the players are fresh. When walking on the toes, the postural control is challenged by moving the center of gravity higher up and minimizing the support surface. The exercises can be progressively facilitated by exercising with various activities, e.g. including the upper extremities at the same time. A typical exercise can be walking forward slowly while moving a bold around the body. The focus is on the postural control, which is defined as achieving, maintaining or restoring a state of balance (Læssøe, 2017). Exercises that challenge postural control can also be combined with mobilizing exercises such as exercises for the groin (e.g. "Sumowalk").

Figure 1. Elite female team handball players working with postural control in soft sand while also including the upper extremities. Right picture shows a player performing lunges.

A well-known exercise is lunges (see figure 1). Lunges is defined as all positions where one leg is positioned forward with the knee bent and foot flat in the ground, and the other leg is placed behind with only the forefoot in the ground. This exercise can be performed with varying degrees of difficulty, e.g. walking forward, backwards and with rotation. Another version is "Sumowalk", which is defined as "walking deep squats". The player stands with the feet placed in shoulder distance. The back is kept straight. The knees and the hip is bended as deep as the player can do without bending the back and without tilting in the pelvis. The knees must move in the same direction as the foot. In addition, the knees must be pushed out to the side. The players must then stretch the legs and get back to the starting position, then turn 180 degrees and do it again. The unstable sand surface will help to challenge the movements in the ankle, knee and hip joint. The "Sumowalk" focuses on the outward rotation of the hip joint, and the alignment over the knee joint.

Jumping

Landing on both legs

The primary focus is on balance and alignment in the landing, which is the most ideal position of the body segments, relative to the environment and in relation to gravity. The players must keep the balance before the next jump. In total, the players perform sets of 16 jumps (4 x 4) depending on the level of the players - 4 times forward, 4 times backward, 4 times sideways to the left and right, respectively. Relatively long pauses between the sets (1-2 min), thus focusing on neuromuscular training and the quality of the exercises.

Landing on one leg

The exercises are executed in a square. Again, they are primarily focusing on the neuromuscular training aspect. It is important to maintain the position after landing in 3-5 seconds. Depending on the quality of the landing and standing position, the player must jump up 6-8 times on each leg. The players must remember that the focus is on quality (balance and alignment) and not on physical training. Progression of the activity is increasing the jumping height, but again this will depend on the players balance and alignment when landing. Training to achieve an optimal balance and a well-coordinated movement in soft sand is about using feedback from the body's sensory system to optimize the players' balance in general. The feedback information will be processed into new and more optimal motor programs, which the player can use to adjust his or hers next movement if it is necessary to improve the performance. The player will have gained a feedforward strategy, which is a new pre-calculation of the upcoming movement. To maintain the balance, the player will try to work anticipatory on the basis of feedforward strategies (Læssøe, 2017).

Table 1. Examples of beach handball exercises used as rehabilitation and prevention training in soft dry beach sand.

Activity	Focus	Training effect
Walking in different ways (forward/ backward/on toes).	Quality in movement and balance.	Training sensory motor skills and postural control.
Running with low speed (forward/backward/sideways/slalom). Progression: Running in pairs and two or three and playing with a beach handball.	Running quality and balance.	Proprioceptive and exteroceptive training.
Lunges and "Sumowalk".	Challenging the ankle, knee and hip joint. Quality in movements, alignment and balance.	Joint movements and proprioceptive training.
Jumping and landing on both legs and one leg (forward/ backward/ sideways).	Challenging the ankle, knee and hip joint. Quality in movements, alignment and balance	Proprioceptive and exteroceptive training. Ankle stability.
Kettlebell swing.	Alignment, balance and quality in movement.	Proprioception and neuromuscular activity in the hamstrings and ankle stability.
Kettlebell Thruster.	Postural control and stability of the lower extremities.	Proprioception and neuromuscular training in the ankle, knee and hip joint, and core stability.

Kettlebell exercises

Kettlebell swing has shown to be one of the best exercises to activate m. semitendinosus (Jensen et al., 2010). Studies have also demonstrated that an increased ratio between m. semitendinosus and m. biceps femoris neuromuscular activity may help to prevent excessive external rotation of the tibia and lateral joint compression during side cutting manoeuvres in team handball (Zebis et al., 2013). In addition, it has been shown that neuromuscular coordination deficit after anterior cruciate ligament (ACL) reconstruction can be modulated by 6 weeks of kettlebell training in elite female soccer players (Zebis et al., 2017).

When training kettlebell swing in soft beach sand, the balance and coordination will be challenged primarily because the soft sand surface creates an unstable foundation and therefore heavily involves the muscle activity around the knee joint and further up to the hip joint. Kettlebell Thruster is another exercise that challenges the postural control when preformed in soft beach sand (see table 1). The exercise is basically a combination of a squat and overhead press. The squat provides the momentum to drive the kettlebell up and into the top position. When performing the exercise, the kettlebell stays in a racked position and does not swing throughout the movement. The players must use the power of the legs to drive the kettlebell up and into the top position, and have a primary focus on stability and balance.

Training in sand has the same purpose as similar training on an unstable surface like a gymnastics floor mat. Training in sand is based on both stability and agility training (through balance improvements, moving strategies and proprioception), which can help reduce the risk of injury and secondary improve performance (Læssøe, 2017). A study with young team handball players training balance and coordinative exercises in soft beach sand compared with training on an indoor court indicated that training in soft sand may be an effective form of training for ankle stability and balance (Andersen et al., 2015). During a pre-season training period (especially early in this period), team handball players may experience a high incidence of overload injuries, if the progression of training is not optimal (implementation of too much high-intensity or large-volume training too fast). The lower impact forces seen in the sand may enable the players to increase the overall physical load for a given exercise. Thus, training in sand can be an appropriate alternative to a hard indoor court especially during rehabilitation training.

Beach handball exercises that focus on alternative physical training

Training in soft sand provides an opportunity to improve the fitness of the players with a reduced risk of muscle damage and aches. This may be because overload juries will not occur as often when the training is performed with variable loads because of the soft, variable surface compared to training and landing on a harder surface with constant, uniform loads. Moreover, the lesser the ground reaction force compared to the indoor court will also reduce the impact on the muscles, tendons and joints. Beach handball exercises in soft sand can therefore be used as an alternative training surface for indoor team handball in the pre-season period. This training could permit a higher training load in selected training sessions and at the same time reduce the subsequent muscle damage and aches, which often follow high-intensity training.

Studies from other team sports have shown that training in sand causes a higher energy consumption and a lower strain compared to the more traditional team sport surfaces like grass and indoor courts. This may be due to many factors, including a rise in work because of the absorption of muscle energy by soft sand (Lejeune et al., 1998; Pinnington et al. (2005), and a reduced utilization of the elastic energy (Zamparo et al., 1992). It can also largely attributable to an increased need for stabilization around the hip, knee and ankle by movements on an unstable surface like soft beach sand. It seems that by training in sand the players recover faster as the individual muscles are loaded less, but the benefits of functional physical training in sand will likely occur because more muscle groups will be activated while moving in sand compared to moving on a harder surface. However, it must be emphasized that for team handball players without any injuries, this type of training is only suitable as alternative training physical training in a relatively limited amount in the pre-season period.

Exercises with focus on aerobic performance

Since beach handball exercises, especially on soft sand, is very energy consuming and thus physically challenging, these exercises are not well suited for aerobic low-intensity and moderate-

intensity training, respectively, (for training definitions, see Michalsik, 2015) unless the sand is wet and relatively hard. Instead, the exercises should be used for aerobic high-intensity training, e.g. performed with short intervals (see Michalsik, 2015). Examples of aerobic high-intensity training performed with short intervals can be sets of 20 sec running and 10 sec. resting with 6 repetitions corresponding to an intensity of 80-90 % of max. HR.
An example of an exercise could be running in intervals on a beach handball court (see table 2). The players are together in groups of three players - two are running and one is resting. The two players, who is running, moves in the 15-m field at the middle of the court. Each exercise bout consists of 4 x 15 m running and in 2 x 15 m resting. The players change continuously resulting in about 20 sec running and 10 sec of resting performed with 6 repetitions in a set. 2 min pause between each set. The number of sets will depend of the physical level of the players. The ball can be included, e.g. the resting players can drop a ball on the court each 30 m who must be picked up by the running player.

Exercises with focus on anaerobic performance

Due to the absorptive qualities of sand, beach handball exercises are well-suited for anaerobic training. However, anaerobic training is not performed regularly in the pre-season period for team handball players. This is due to the physiological elements, which are decisive for the anaerobic performance, can be increased relatively fast, e.g. the activity of the glycolytic enzymes can be enhanced in a month with the right training (Michalsik, 2015). Consequently, since anaerobic training is mentally and physically stressful, there is no need for intensifying anaerobic training before the competitive season is approaching. In addition, specifically speed training is not optimal to perform on soft beach sand because of the high importance of the right coordination while sprinting. The movement transfer to the normal team handball court seem not to be ideal. Nevertheless, examples of anaerobic beach handball exercises training would be:

Speed endurance training

Production training

Four beach handball teams consisting of three players each are exercising on the beach handball court (see table 2). Two as defending teams, one working as an attacking team in both ends, and one is resting. The attacking team is working alternately at both ends in 20 sec (4 to 5 attacks) before taking a pause. There will continually be a change of positions. One of the defending teams will now step in as an attacking team, and the resting team will step in as a defending team. The exercise intensity should correspond to 80-90 % of max. intensity, and there should be 4-6 repetitions in an entire circle depending on the level of the players. The ratio between exercise and rest should be 1:10 (Michalsik, 2015).
Another exercise is performed two and two together with resistance bands (see table 2). One player is running forward while the other is creating resistance by holding the running player back. 60 m running (3 x 20 m) at high intensity corresponding to 90 % of max. intensity, which takes around 15 sec. Again, each player should perform 4 - 6 repetitions depending on the level of the players, and the ratio between exercise and rest should be 1:10. The exercise can be organized in larger groups, so the player creating the resistance will get a proper rest period.

Tolerance training

Continuous fast breaks in group of three players running with high intensity for 1 min back and forth on the beach handball court without any defence while playing together with the ball in different running patterns and shooting in each end (see table 2). The exercise intensity should correspond to around 50-70 % of max. intensity, and the ratio between exercise and rest should be 1:3. The first group of players run for 1 min, then a new group of players run for 1 min etc. In this example, a total of 12 players will be performing the exercise. The number of repetitions should be 3-5 depending on the level of the players.

Agility and jumping training

When it comes to training agility and jumps, a few studies and practical experience indicate that adaptations from training in sand may have a positive influence on the physical performance on an indoor court. A study in beach volley showed that training in soft sand during squat jumps and running may activate more muscular fibres due to the varied surface and compliance in sand (Gortsila et al., 2011). This may increase muscular activity during jumping and agility related activities on a hard indoor court. After 10 weeks of sand agility training three times a week training, improvements were demonstrated in an agility test performed both in sand and on a solid surface. It may suggest that the physiological and biomechanical adaptations specific to training in sand, may also have a positive effect on agility performance on solid surfaces like an indoor team handball court (Gortsila et al., 2011).

Impellizzeri et al. (2008) studied the effect of plyometric training for a 4-week period with three training sessions per week in soccer players, either in soft sand or on grass. Both the sand and grass interventions resulted in improvements in both a 10 m and 20 m sprint on solid grass surface. However, there were differences in the enhancements in the jumping heights between the two groups. Training on grass resulted in greater improvements in counter-movement jump compared to the sand group, which may be due to a loss of elastic energy in muscles and tendons. Nevertheless, there was a major improvement in squat jump (SJ) in the sand training group,

Table 2. Examples of beach handball exercises used as alternative aerobic and anaerobic training in soft dry beach sand.

Activity	Focus	Training effect
Running back and forth in 15 m field in the middle of the beach handball court. 3 players are running alternately two at a time. 20 sec running and 10 sec pause. Sets of 6 repetitions with an intensity corresponding to 80-90 % of max. HR.	Aerobic high-intensity training with short intervals.	Aerobic power, maximum oxygen uptake.
Four beach handball teams consisting of three players each. Two working as defending teams, one working as an attacking team in both ends, and one is resting. The attacking team is working alternately at both ends in 20 sec (4 to 5 attacks) before taking a pause. The exercise intensity should correspond to 80-90 % of max. intensity, and there should be 4-6 repetitions in a whole circle. The ratio between exercise and rest should be 1:10.	Production training	Improving the ability to rapidly develop energy through anaerobic processes and the ability to recover after intense exercise.
60 m running (3 x 20m, 15 sec) with a resistance band at high intensity corresponding to 90 % of max. intensity. 4 -6 repetitions per player depending on the level of the players, and the ratio between exercise and rest should be 1:10. The exercise can be organized in larger groups, so the player creating the resistance will get a proper rest period.	Production training	Improving the ability to rapidly develop energy through anaerobic processes and the ability to recover after intense exercise.
Continuous fast breaks in group of three players running with high intensity for 1 min back and forth on the beach handball court without any defence while playing together with the ball and shooting in each end. The exercise intensity should correspond to around 50-70 % of max. intensity, and the ratio between exercise and rest should be 1:3. The number of repetitions should be 3-5 depending on the level of the players.	Tolerance training	Improving the ability to continuously develop energy by anaerobic processes and the ability to recover after intense exercise.

Agility exercises

These exercises will primarily target lower extremities. The focus is on the position of the ankle, while making a change of direction in soft beach sand. The position of the ankle joint will vary each time the foot hit the soft sand surface. This will probably challenge the muscle groups around the ankle, knee and hip with a greater variety than performing the similar exercises on an indoor court.

Thus, an increased muscle activity is needed for stabilization around the individual joints, especially in the take-off phase in the running cycle. Soft sand agility training may secondarily minimize the overload on the active muscle-tendon unit, because it distributes the load over a larger part of the muscle (e.g. the calf muscle) due to various positions of the involved joints.
All agility exercises have a primary focus on the quality of the movement. The players perform running at moderate speed, but with maximum force during take-offs and changes of direction including backwards and sideways running. The ratio between exercise and rest should be around 1:4, e.g. running for 10 sec and resting for 40 sec. Each player should perform 6-10 repetitions depending on the level of the players. Progression of the exercises may include slalom running and the use of kettlebells (see table 3). An example of the latter could be that the players run slalom around six cones. They start without a kettlebell. When they reach a specific cone, they lift a kettlebell while changing direction. Thus, the load on the lower extremities and on the core muscles increases. They run with the kettlebell to the next cone, and leave the kettlebell there. In this way, the exercise can be varied.

Table 3. Examples of beach handball exercises used as agility training in soft dry beach sand.

Activity	Focus	Training effect
Running with low speed with powerful changes of direction and take-offs.	Quality of movement, alignment and forceful take-offs when changing direction.	Neuromuscular activity, proprioceptive and exteroceptive training.
Running with low speed with powerful changing direction and take-offs between cones (5 m apart) on the beach court. Running for e.g. 5 sec - rest 30 sec with 4-6 repetitions.	Quality of movement, alignment and forceful take-offs when changing direction.	Neuromuscular activity, proprioceptive and exteroceptive training. Ankle and knee stability.
Slalom run around 10 cones. Running for e.g. 5 sec - rest 30 sec with 4-6 repetitions.	Quality of movement, alignment and forceful take-offs when changing direction.	Neuromuscular activity, proprioceptive and exteroceptive training. Ankle and knee stability.
Slalom run around 6 cones with a kettlebell. Running for e.g. 5 sec - rest 40 sec with 4-6 repetitions.	Quality of movement, alignment and forceful take-offs when changing direction. Truncus stability then lifting the kettlebell.	Neuromuscular activity, proprioceptive and exteroceptive training. Ankle and knee stability.

Jumping exercises
When jumping, focus will be on the muscle chain from m. gluteus maximus to the calf muscles. A widely used jumping exercise is squat jumps performed both forward and backward with focus on both jump height and jump length (see table 4). The players should hold the position in 5 sec before jumping again. They can also be executed with 180 degrees rotation in the air. Here, the primary thing is the jump rotation and on the landing. At landing, the focus will be on the eccentric work as shock absorption, as well as on the neuromuscular coordination in the landing in the unstable soft sand. Series of 6-8 repetitions should be performed with two players working alternately in pairs. Jumping lunges is another well-known exercise (see table 4). Again, the players are working alternately in pairs. The exercise is very strength demanding with excellent training of the neuromuscular coordination.

Table 4. Examples of beach handball exercises used as jumping training in soft dry beach sand.

Activity	Focus	Training effect
Squat jumps performed forward and backward. The players are jumping alternately in pairs. Hold the position in 5 sec before jumping again. 10 repetitions in 2-4 sets.	Quality in movement and balance when jumping (height and length) and landing. Muscle chain from m. gluteus maximus to the calf muscles.	Developing explosive force in the direction of the movement. Proprioception, neuromuscular activity and ankle, knee, hip and truncus stability.
Squat jumps performed with 180 degrees rotation in the air. The players are jumping alternately in pairs, Hold the position in 5 sec before jumping again. 10 repetitions in 2-4 sets.	Quality in movement and balance when jumping and landing.	Developing explosive force in the direction of the movement. Proprioception, neuromuscular activity and ankle, knee, hip and truncus stability.
Jumping lunges. The players are jumping alternately in pairs. 10 repetitions in 2-4 sets.	Quality in movement and balance when jumping and landing.	Developing explosive force in the direction of the movement. Proprioception, neuromuscular activity and ankle, knee, hip and truncus stability.

Training in soft beach sand can have a positive effect on the rehabilitation, prevention and physical training of elite team handball players, but it does not replace the different training methods on indoor courts. Training in soft sand should be considered as alternative training and an excellent opportunity for a different approach to the various training regimens for elite team handball players.

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HOW TO MANAGE CONCURRENT TRAINING IN HANDBALL?

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Summary
This paper is a short literature review aimed to briefly describe the problem of concurrent sprint, strength and endurance training with regard to Handball performance. The main objective is to help handball coaches in managing concurrent training at best.

Introduction

Handball is an acyclic sport which requires high aerobic, speed and strength capacities. Concurrent training (CT) (the concomitant integration of aerobic exercise to resistance training) is then a common practice either during a single session or within a periodized training programme. However the resulting effects of CT on performance remain still controversial. Given the multitude of possible factors able to modulate the CT effects, the potential roles of individual training variables in acute and chronic interference are not fully elucidated. This short review aims to summarize the main factors playing a role in the CT effects, to briefly introduce the underlying molecular processes and to deduce as far as possible the main practical recommendations to maximize the benefits of resistance and endurance training in handball.

Concurrent training effects

The CT effects are not univocal : Since the original work of Hickson (1980), many studies conducted in humans found that combination of aerobic and strength training may attenuate gains in muscle mass compared with undertaking resistance training alone (Fyfe et al., 2014). This has been variously described as the interference effect. This negative outcome was previously attributed to the low volume and frequency of training undertaken, or to a too limited intervention period. Surprisingly training-induced gains in aerobic capacity are not so compromised by CT, although smaller gains in aerobic capacity with concurrent versus endurance training alone have been reported. Both short (<15 min) and long-duration (>30 min) endurance performance has been shown to increase with CT, predominantly via improvements in neuromuscular function and economy (Aagaard et al., 2011).

Concurrent training factors

As for single mode training, a multitude of potential factors might modulate the interference effect and contribute to explain the previous data. But only a few of them have been studied.

1. Heterogeneity in the Training Response**:**

The heterogeneity of individual responses is well known. Even when subjects participate in carefully controlled exercise programmes, the training responses may be very different, leading to the classification of non, low, high and even adverse responders (Bouchard et al., 2012). This interindividual variability includes a strong genetic component. The results of studies of individuals undertaking resistance and endurance training alone suggest that 'low responders' to each exercise stimulus may be as high as 25% (Gurd et al., 2016). Thus, it might be expected that the number of 'low responders' would at least increase after CT compared to single mode training. But the little data currently available suggest that individuals are not systematically low or high responders when exposed to different training stimuli (Coffey et Hawley 2016).

2. Training status :

To investigate this point, Coffey et al. (2009) studied highly trained athletes with a prolonged history of either endurance or strength training (but not CT) who performed both an acute bout of exercise in their specialised discipline and then ''crossed over'' and undertook a bout of unfamiliar exercise. Muscle biopsies were taken at rest, immediately and 3 h post exercise. Molecular endurance adaptations appeared after cycling in strength-trained but not endurance-trained subjects and molecular resistance adaptations in endurance but not strength-trained subjects. For the authors, these results clearly demonstrate that prior training history alters the exercise specific molecular responses involved in single mode adaptations to training.

3. Training variables :

It appears more than likely that various training variables play a significant role in the concurrent interference effect as well.

Within-Session Exercise Order **:** Most studies observed an interference effect when high endurance exercise precedes resistance exercise. Theoretically, muscle glycogen depletion and residual fatigue from prior endurance exercise may alter subsequent resistance performance. Then undertaking resistance exercise prior to endurance exercise may alleviate these negative effects. Indeed a few performance-based data found that performing resistance exercise prior to endurance exercise appears to have little negative effect and may even slightly increases aerobic capacity both in top-level endurance athletes (Aagaard et al., 2011) and in rugby players (Robineau 2016). Consequently, it was recommended that resistance training precedes endurance exercise if performed within the same session.

Between-Mode Recovery Length: Potentially, any intense (endurance or resistance) exercise may induce residual fatigue which compromises the intensity of the following bout and the subsequent expected adaptations. Allowing adequate recovery between concurrent exercise sessions may therefore attenuate any interference effect. Indeed, following a bout of endurance exercise, force production is reduced for at least 6 h, returning to baseline by 24 h post-exercise (Bentley at al ; 1998). Interestingly, Robineau et al. (2016) investigated the effects of a 7-week CT with 3 recuperation lengths (0h-6h-24h) in rugby players. Strength exercises were always performed before high-intensity interval running sessions (15s-15s). They observed that gains in maximal strength for bench press and half squat were lower after 0h compared with those after 6h and 24h. They concluded that daily training without a recovery period between sessions (C-0h) and, to a lesser extent, training twice a day (C-6h), is not optimal for neuromuscular and aerobic improvements. In their meta-analysis of CT literature, Wilson and colleagues [12] also observed a trend (non-statistically significant) towards greater hypertrophy gains in CT studies when resistance and endurance training were performed on separate days compared with on the same day.

Endurance Exercise Intensity : As many team sports, handball is characterised by frequent intermittent running and sprinting. Thus high intensity interval training (HIT) is often used to enhance maximal aerobic power, oxidative capacity as well as anaerobic capacity and/or repeated sprint ability. However studies regarding the effects of incorporating HIT in a CT regime are scarce and focused on muscle molecular responses. The study of Coffey et al. (2009) showed that repeated sprints (ten 6-s maximal sprint efforts on a bicycle 15 min) attenuated the anabolic response when performed before strength training, and more than with moderate-intensity continuous cycling. These findings are consistent with other data showing that markers of the muscle anabolic response are not affected by 30 or 45 min of cycling at 70 % VO2max respectively performed 15 min or 6 h before performing resistance exercise (Lundberg et al., 2012). It seems then likely that the interference effect is mainly induced by HIT rather than by moderate and continuous endurance training.

Endurance Exercise volume : The role of endurance exercise volume is supported by studies which report more important attenuation of strength and muscle hypertrophy with greater frequencies of concurrent endurance exercise (3 days per week) than when endurance exercise was performed only once or even twice per week (McCarthy et al., 2002). In addition, the meta-analysis of Wilson et al. (2012) clearly demonstrates that the interference effect of endurance exercise on muscle hypertrophy, strength and power occurs in a frequency and duration dependent manner. Thus low-volume HIT protocols might confer benefit when incorporated into a CT programme by preventing interference effect, whilst also improving aerobic capacity.

Endurance Exercise Modality: Like the majority of team-sports, handball uses running as the predominant aerobic training modality. However arms and upper body are also highly involved in handball and high levels of arms strength and velocity are important factors for successful throws. Interestingly, the majority of CT studies reporting an interference effect have incorporated running rather than cycling as the endurance training modality. For Coffey et al. (2009), the interference effect seems greater with running than cycling possibly due to the eccentric component of running and concomitant muscle damage. Interestlingly also the meta-analysis of Wilson et al. (2012) observes no decrements in upper-body strength, or hypertrophy when running is incorporated in CT. The authors suggest that the interference effect of endurance training with strength training outcomes is body part specific and not systemic.

4. Acute *vs* chronic concurrent training :
All the aforementioned data result from short-term CT programmes. Of note is that the original study by Hickson showed no detectable interference effect until the 8th week of CT, suggesting that a minimal training level is needed for triggering interference. However there are limited data on long-term performances associated with chronic CT. For Fyfe et al. (2014) it seems likely that chronic CT might modulate acute interference responses over time, similar to that seen with single mode training.

5. Nutritional status :
Detailed investigation of the nutritional requirements for CT has not been conducted, and our current knowledge about nutritional strategies that may influence the CT comes from isolated studies examining the impact of nutritional interventions on endurance or resistance training alone. Endurance athletes use a range of dietary strategies to improve performance, with maximizing glycogen stores as a key strategy for many. In strength disciplines, accent is turned towards protein intake which is often increased above the current nutritional recommendations. However both endurance and strength athletes should know that post-exercise intakes of an adequate combination of proteins and carbohydrates may provide substantial benefits for further succesfull performance (Perez-Schindler et al., 2014). It is now recognized that addition of high quality proteins to carbohydrates intake is crucial after high endurance exercise to repair muscle damage and to promote muscle glycogen synthesis. As well, addition of carbohydrates to protein intakes during what is called the‘‘anabolic window » after resistance exercise results in enhanced rates of muscle protein synthesis.

Mechanisms underpinning the concurrent training effects
Skeletal muscle adaptation to exercise is highly dependent on the specific type of training performed. By stimulating the myofibrillar proteins synthesis for muscle hypertrophy, heavy resistance training increases muscle strength and power. In contrast, endurance training enhances aerobic endurance by increasing the mitochondrial content and respiratory capacity of the trained muscle fibers, resulting in a slower rate of utilization of muscle glycogen, a greater reliance on fat oxidation, and less lactate production during submaximal exercise. It now appears that the genetic and molecular mechanisms of adaptation induced by resistance and endurance-based training are distinct, with each mode of exercise activating and (or) repressing specific subsets of genes and cellular signaling pathways. Briefly, experiments in humans and rodents demonstrated that a single bout of resistance exercise or endurance exercise activates two different signaling pathways within the muscle. Whereas acute resistance exercise activates the mTOR (mammalian target of Rapamycin) pathway and thereby stimulates muscle protein synthesis, acute endurance is associated with signaling mechanisms related to metabolic adaptations, such as the activation of the AMP-activated protein kinase (AMPK) signaling pathway. Of particular interest is that experiments in rodents found that activation of AMPK by endurance exercise may inhibit mTOR signaling and suppress resistance-exercise-induced muscle-protein synthesis. Thus training for both endurance and strength within a CT programme would result in a compromised adaptation, compared with

training for either exercise mode alone. As previously mentioned, the mechanisms of the interference effect are likely to be multifactorial. Presumably endurance exercise either interferes with the ‘quality’ of resistance exercise sessions (via residual fatigue and/or substrate depletion), and/or compromises the acute molecular responses activated by resistance exercise that mediate fiber hypertrophy. Various studies have attempted to detect such ‘molecular interference’ in humans; but, to date, these studies have failed to replicate an acute interference mechanism as distinct as that observed in rodents (Fyfe et al. 2014). Interestingly recent works in humans (Wang et al.; 2011) observed that resistance exercise, performed after endurance exercise, amplifies the adaptive signaling response of mitochondrial biogenesis compared with single-mode endurance exercise. Those results are consistent with previous performance-based data showing that CT may be sometimes beneficial for the adaptation of muscle oxidative capacity.

Practical recommendations

Of course, further research is required to deep our knowledge on this field. However, some simple nutritional and training strategies can be devised to handball coaches in order to maximize the adaptations to CT. Overall power is the major variable, which is affected by CT. However, CT may not lead to significant decrements in strength and hypertrophy, if proper timing and modality of endurance training are selected. If the main goal is to develop muscle strength and power, the most practical approach to combine endurance and resistance training within the same day is likely an endurance session in the morning, followed by resistance training in the afternoon. As in rugby, coaches should avoid scheduling both qualities with less than 6-hour recovery between them. Coaches should select endurance running exercises at very high intensities such as low volume-HIT programmes which more closely approximate handball activity. Another alternative is to restrict strength exercises of the upper body during the afternoon session. But, at the beginning of the season, the main goal may be to improve endurance capacity to lower-intensity endurance training sessions. Then performing a strength session immediately after a low-intensity endurance session results in a greater stimulus for endurance adaptation than the low-intensity endurance session alone.

Nutritional recommendations may also help handball players to support CT and to prevent the interference effect. When there is less than 6–8 hours between endurance exercise and subsequent resistance exercise resynthesis of muscle glycogen levels is highly stimulated by consuming carbohydrates-rich foods and drinks as soon as possible after the first exercise. The concomitant intake of ~10 to 20 g of high quality proteins is also recommended. After the resistance training session and during the ‘‘anabolic window, the consumption of leucine-rich proteins is particularly effective in promoting protein synthesis. If resistance exercise is performed later in the day, it becomes even more important to consume leucine-rich proteins immediately prior to sleep to maximize the synthetic response overnight. An efficacious beverage to consume after exercise is flavoured milk that contains added simple sugar. This beverage provides fluid that is better retained than water and isotonic sport drinks, carbohydrates to restore muscle glycogen, and high-quality proteins to repair and facilitate adaptive changes in protein synthesis.

Conclusions

Even if the potential factors and mechanisms involved in the CT effects are not fully elucidated, some specific exercise training recommendations combined to nutritional startegies appear to be effective in preventing the interference effect and may help coaches in managing CT in handball.

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EXPERIENCES WITH A HANDBALL GAME-BASED APPROACH. CHALLENGING TRADITIONAL TEACHING METHODOLOGIES

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Summary
The potential of a **Handball Game-Based Approach** to enhance game play for both beginners and proficient players is examined throughout a series of structured practice experiences in physical education and coaching. A series of experiments implementing this approach in various settings were performed and results are promising.

Keywords: teaching games for understanding; creative play

Introduction

Handball is a fast-paced game, which requires players to anticipate and make decisions faster than their opponents to get an effective time-space advantage, and those players who make quicker, creative and more accurate decisions are recognized as intelligent players. These players exhibit game knowledge and superior anticipatory skills compared with less skilled players. These players usually are placed in key playing positions, such as central back (play maker position). Currently, practitioners believe that these skills are innate traits, meaning that there is little room for its development. Because of these beliefs, much more effort is placed on developing talent detection and selection systems, instead of its effective coaching/teaching.

Over the past decades, several authors have outlined the need of different teaching/training approaches if one intend to develop players able to read and understand what is going on around them and to successfully influence the game course. A *major* contribution for these new trends was done by Bunker and Thorpe (1982), with the original formulations about Teaching Games for Understanding. Afterward, other developments emerged, namely through the Tactical Games Approach (Griffin, Mitchell & Oslin, 1997), Play Practice (Launder, 2001), Game Sense (Light, 2004), and Invasion Games Competence Model (Musch *et al*., 2002).

For example, in a classical session, face-to-face *overarm* passing exercises without opposition are repeated session after session, where the passing instructions are mainly focused on proper throwing technique. But, why are there so many ball possessions lost because of passing mistakes during competition? To help understand this problem, we should observe the game play situation where the mistakes took place, and to understand why they happen. Is it a motion-technique problem or is there a perceptual and decision-making problem? Do they know how to see the game-play surroundings (picking up the relevant information) and how to respond to the situational playing constraints?

Despite the increasing importance of game understanding and decision-making in skilful play, the technique-approach is still seen to be quite predominating in handball practices. As a consequence, the techniques and motor skills are over-taught and emphasised in isolated situations (outside the game context), in a mechanical way.

Also *schemes of play* are taught before players can grasp their significance from a tactical or strategic point of view, being repeated in stable and protected conditions, with near-total absence of creative or critical thinking. With beginners, these game solutions may result as a consequence of opponents' *naivety*, or simply because of fast execution. But, with time, we may see players who know how to perform these collective actions without opposition ("on dry"), but in real competition, when the opponent anticipates their moves, creating different problems from the ones that were expected, they are not able realize it and to easily adapt to find another solution.

But developing intelligent players is a hard and long process that sometimes does not lead to immediate success. On the other hand, it is much easier to use analytical/technical-based approaches, where the players are trained to use pre-determined moves and to be quite successful in youth categories. An additional problem is the use of the 6:0 lined-up defensive system, with the players back positioned and very closed, giving little or no room for the pivot play and gap attacking actions. Additionally, because of low physical and technical capacities of wingers at very young ages, it is also common to see coaches encouraging the first defender not to defend the winger but to be more inside-positioned instead. This behaviour results in a more compact defensive wall in the middle of the defence, being almost impossible for beginners to find an open scoring opportunity in the frontal zones of goal, while being more prone to physical contact.

There is no denying that even in the highest levels, there are some quite successful handball coaches using the traditional approach. They are using set play after set play and discourage players from reading the game play and thinking to find more clever solutions.

The view presented here is that we need to use a more constructivist and cognitive perspective (tactical or game-based approach), as the traditional technique or behavioural approach fails to enhance skilful or intelligent and creative play. It is, therefore, important to distinguish between tactical knowledge to deal with dynamic situational playing constraints (or configuration of play) from successful set play (pre-established collective moves).

Educators should be aware of how players better learn to decide what to do, when to do it and how to do it to meet the demands of a dynamic and time-space pressuring environment as found in handball; and how players better develop their technical skills, being able to use them in a flexible way in order to efficiently beat opposition. In this way, educators are challenged to design creative and effective learning settings that will help players master these dynamic environments.

Handball game-based approach

According to the recommendations in *Teaching Games for Understanding* (Bunker & Thorpe, 1982), the approach to teaching Handball presented was designed to elicit the player' tactical awareness and playing skills, and game play quality (Estriga and Moreira, 2014).

In the Handball Game-Centred Approach, it is proposed to gradually expose beginners to increased levels of complexity, and possibilities of action through modified game forms (4v4, 5v5, 6v6), step-by-step, until the formal game (7v7), according to their readiness and learning goals.

Therefore, it is essential that beginners be faced with suitable and challenging game forms, in terms of tactical understanding, effective involvement, game appreciation, playing possibilities, and physical/technical requirements. Based on these assumptions, modified game versions are proposed to create a competitive, challenging and enjoyable learning environment. So, the beginner is confronted with the need to understand the game (including its rules), the main game principles and how to play it through an authentic game play experience. Within the context of the game, the players are encouraged to recognize the game problem, and to explore options. It is the situational game play configuration that determines the tactical options (*what to do* and *when to do it*). Technical skills must be taught according to their usefulness in solving tactical problems and not the opposite. Note that even with rudimentary motor skills, they can immediately start to play handball and to reach the objectives. The passing technique is very easy to master, particularly when a suitable ball is being used (small and soft).

The educator's competence to realize the learners' play level and their needs is of great value for effective handball teaching or coaching through the game-based approach. Therefore, the educator is challenged to modify and shape the game play settings to suit learners' development level, manipulating key playing constraints during a game and learning tasks through a scaffolding and empowerment process.

In the following table, the major guidelines usually provided to practitioners to decide which game form to work first are presented.

Table 1. How to decide which game form to address first (adapted from Estriga & Moreira, 2014)

MAJOR GAME PROBLEMS		SHAPING GAME PLAY SETTINGS
If players struggle to keep ball possession and to progress toward goal when facing defensive pressure; they never/rarely reach goal	→	**Level I – First Basic Game Form** A game form based on numerical advantage, namely 4v4, where the goalkeeper joins the attack, creating outnumbered play (4v3), should be addressed first. The 3v3 and 4v4 game form (plus goalkeepers) may also be adopted as long as no individual defence is applied or another kind of defensive organization
If players are able to keep ball possession and to progress to goal when facing defensive pressure, but still are struggling in setting up open scoring opportunities	→	**Level I – Second Basic Game Form** Use a game form 4v4, plus goalkeepers, with high/open defensive pressure, emphasising exploring transitional play and game play without ball to get open
If defenders are not able to keep high defensive pressure, being unable of avoiding opponents from getting open, stooping fast ball progression, and therefore, allowing opponents to setting up easy scoring opportunities	→	**Level II – Third Basic Game Form** Bring into play a game form with a more closed and lined-up zone defence (4v4, plus goalkeepers), focusing on wide attacking play and breakthrough defence organization (enhancing playing skills with ball)
If attackers are able to easily set up a score opportunity when facing a zone lined-up defence, within a small sized court, because of skills improvement and physical development (as a consequence of pubertal growth spurt)	→	**Level III – Fourth/Fifth Basic Game Form** Introduce a more complex game form in a bigger court size (*i.e.* an almost or formal size), namely 5v5, plus goalkeepers. At this level, the transitional and positional play should be mastered, focusing on wide attacking play, breakthrough skills and interior pressure play (the pivot role).

In this approach, coaches/teachers are called on to clearly diagnose the game problems, and not just its symptoms. The problems/situations they encounter and are not able to solve properly are, therefore, the tools and the main content of the teaching process. The educators must be able to identify game problems, prioritizing and sequencing what to teach and how, according to his/her working conditions/barriers.

The game problems should be broken down into smaller/isolated game problems – the learning tasks –where the learners will have the opportunity to work in a deeper and more systematic way according to their needs. Therefore, a permanent exchange between the introduced game form (the macro learning context – ***game form***) and reduced/shaped learning tasks (micro level - ***partial game forms*** *and* ***game-based tasks***) should be kept until a further step into a new, more complex, game form can be taken. It is, therefore, a process which always revolves around the *game*.

The learning tasks not only allow to adapt the problems to the beginners level, through *simplifying or exaggerating* strategies, but also to enable them to occur innumerable times. In this way, the players have the opportunity to explore and to try different solutions, can make mistakes and learn from mistakes, while practicing technical skills in a more authentic way (tasks like the game). If the learners show severe difficulties in finding solutions by themselves, the educator should *freeze* the situation/problem and, by using questioning strategies, should help/guide them to recognize the problem (playing constraints), to clarify the applicable game principles (or tactical aims), and to focus on **what, when** and **how** to do it to address the problem (*e.g.,* action rules with and without ball).

Therefore, the learning tasks have utmost importance in exercising and improving the ability to recognize playing patterns (what to see, what kind of clues to value?) and to formulate realistic expectations on the behaviour of the various teammates and opponents, enabling beginners to act in

anticipation which means enhancing the ability to make clever and quick choices. Therefore, players are more likely to bring into real play settings (game forms) new skills if they were learned in similar decision-making sceneries and/or technical-execution constraints.
In this work we focus more deeply our experience in implementing this approach in a specific European country with young players of many diverse backgrounds.

Methods
An action-research was carried out within the context of several courses and interventions in real practice settings, where the investigator/lecturer is always engaged within a critical thinking, reflexive process about the practitioners' beliefs, conceptions, methods/styles, and how to best influence them to rethink-their handball approach and to challenge them to try new ideas.
The work presented in this paper has been patiently conducted on the basis of conceptual and methodological choices about teaching and coaching handball beginners, in both school and clubs, that has been systematically taught at Porto University and in all places or countries where this approach has been introduced, usually in a three/four full-day basis (with theoretical and practical sessions). In this work, we will focus on practice experience held in a European country, in 2016, not revealed because of ethical reasons. This experiment is part of a long-term handball development project. In this work, only two first phases were analysed:

1) four full days of theoretical and practical instructions about the handball game-based approach (80 participants);

2) observation of PE classes (n=68, in five different regions/cities) and training sessions in real practice settings (club or school) one month after the 4-day course. Two groups were constituted: intervention (n=38) and control group (n=30). This action involved 1490 handball beginners, from different schools/clubs (n=70). Each session had a duration of about 1 hour and 30 minutes. The first hour of each session was dedicated to warm-up, exercises and a game match, as a standard procedure. After it, the investigator/lecturer asked and discussed with each practitioner what the major game problems were and how to design suitable exercises. Subsequently, several learning tasks were tried by the players, while the lecturer had the opportunity to explain to the coach/teacher the purpose of certain tasks and how to manipulate the constraints according to needs. A major focus was put on using questioning and guided discovery, instead of more direct instructional methods to correct decision-making mistakes. All of this was done in a very interactive and cooperative environment.

A final technical meeting with the investigator/lecturer, practitioners and local technical staff from the federation took place in each city.
All the observed practices were video-recorded for further review, analysis and type of tasks confirmation. All critical events, debates, discussions were documented in the investigator's log diary, which was also considered as source of information. An inductive thematic analysis was employed.

Practice experiences: Observation of current practices at clubs and schools
Without being introduced to Handball Game-Based Approach:
The observed practices were constituted by highly structured training sessions, where the players are taught to stay or move in a very organized, controlled and *protected* way; generally, there was no noise, no fun, and no emotion. Most of the time, we could only hear the voice of the practitioner, giving strict instructions about what to do and when. Meanwhile, the players were showing no game initiative, were mainly passively waiting for orders.
The first part was dedicated to warm-up without ball and with ball. At first, the players were engaged with fundamental drills in an analytical way, such as face-to-face static inter-passing drills

or while running, but without any kind of defensive pressure. Also, big queues of standing players waiting for their turn were frequently observed.
Subsequently, a traditional goalkeeper warm-up took place; most often, we observed a big queue of players in front of goal, shooting without any defensive constraints and always with a three-step shot. Also, the goalkeepers were faced with a mechanical warming-up, as they knew in advance where the ball was going to be sent (*e.g.*, upper corner to the right, to the left…).
The majority of the learning tasks were passing exercises without opposition, with a predetermined trajectory. Mostly, the players were organized in two or four spots with several players each, whose goal was to exchange ball without dropping it on the floor, but in a mechanical way (i.e. receiving from and passing to predetermined and fixed sides/spots) without variability in the passing distances, angles or orientations. Also, the bounce was mainly worked with a player dribbling in one straight line from one side to the other, without any defensive pressure.
Major skills worked: passing-catching, bouncing, shooting, defensive positioning and sideways moves.

After being instructed about the Handball Game-Based Approach:
The warming up is mainly constituted of simple lead-up games, dynamic and fun activities. In these sessions there was more disorder, noise, chaos, conflicts among players, but also more emotion.
The fundamental part has composed of passing exercises, mainly with progressing to scoring zones (gaps/spots/targets/gaol) and with shaped defensive confrontation or pressure, according to needs. Usually most of the players were involved in effective activities; they're physical and emotional engaged with the practices. There were very good examples of effective, enjoyable learning environments. There was also much more diversity among the presented learning tasks.
Still there were some (but few) teachers that showed some difficulties in reading the game problems and finding out how to best instruct players to guide them to pick up the relevant information/cues and to act in order to successful solve it.

Focused content: feints, cutting-moves without ball, space awareness, inter-passing skills with pressure (3v3, 3v2, 3v1), functional moving without ball to get opened, wide attacking play, support play, fast transitional play (2v1, 3v2, 4v2+2), fast footwork and fighting for the ball, duels (1v1) with supporters, shooting with defensive constraints, 3v3 in bounded areas, and 2v2, with supporters.

Practical implications
Since the core of game-based or tactical approaches focus on the *hard-to-teach* component of the game, its effectiveness may be compromised if there is a lack of specific game knowledge and problem-reading competences. Consequently, all courses based on these approaches should challenge PE teachers and coaches to deeply understand the game, to clearly identify and prioritize beginners' problems. The game-based approaches are quite demanding of practitioners' backgrounds and skills, contrasting their complexity with a much simpler technical/conditional-based approach. But, no course can be effective if there is no handball appreciation on the part of educator, so this is one of the most important goals to achieve.

Conclusions
Several critics are usually presented to these methods, usually contrasting their complexity when compared with a much simpler technical/conditional-based approach. We have found several things:
*) it is true that a tactical-based approach is much more demanding on the PH teacher/coach as he/she has to identify the root cause of each bad tactical decision and to build a setting to promote the *discovery* of a solution
*) the tactical approach is more rewarding and fun for the players

*) the early focus on the *hard-to-teach* component of the game allows for a development of *smarter* and more proficient players.

From the investigator's/lecturer's perspective, these teaching and practice experiments have been truly empowering and relevant pedagogical experiences. But the practitioners' feedbacks from their results, beginners' enthusiasm, enjoyment and progress in handball, and also parents' caring/involvement is probably the greatest joy the investigator has experienced. One coach said: "you really opened my mind. I experienced and used the traditional approach for more than 40 years, now, I can see and understand the difference.

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IDENTIFICATION OF STATISTICAL DATA MODEL FOR QUALIFICATION OF PRELIMINARY ROUND IN MODERN WORLD MEN'S HANDBALL ENVIRONMENT

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Summary
The purpose of this study was to identify a statistical data model during attacking and defending phases to qualify for the preliminary round in the Olympic Games and the World Handball Championship. We calculated the ratios of shooting plays (xS) and goals (xG) against the possessions and the ratios of expected received shooting plays (xR) and an expected conceded goals (xL) against opposing possessions in 240 men's matches of the preliminary round in men's world handball competitions from 2012 to 2017. Therefore, the values of xS, xG and xL were significantly different between qualifying outcomes. The cutoff values of xG and xL to qualify for the preliminary round were 0.459 and 0.473, respectively. In conclusion, the statistical values such as the xG and xL differ between qualifying outcomes and the cutoff values of xG and xL for qualification were 0.459 in attacking phase and 0.473 in defending phase.

Keywords: quantitative analysis, expected goal, expected conceded goal

Introduction

Numerous research studies have been conducted using statistical quantitative analysis in handball games. Many of these studies（Bilge 2012, Hassan 2014, Ferrari et al. 2014, Saavedra et al. 2017）reported that the variables of game related statistics were different between winning and losing teams. On the other hand, some studies（Rogulj & Katic 2001, Gruicet al. 2006）reported that the variables of those related statistics were similar between match outcomes. These variables of the game related statistics have been a numbers of shots and/or goals, and shooting efficiency (goal/shot) at each shooting play position, etc.

Currently, in soccer, the expected goal (xG) has been used as a good attacking index. The expected goal is the number of goals based on shots taken from a player or team (Rathke 2017). In basketball, the expected possession value (EPV) is beginning to be used to evaluate the player and team Cervone et al. 2016）. In handball, the shot position average model (SPAM) was reposted as an attacking index (Pallamano 2017). The purpose of this study was to identify a statistical data model such as expected goal during attacking possession and expected conceded goal during opposing possession to qualify the preliminary round in the Olympic Games in 2012 and 2016 and the World Handball Championship in 2013, 2015 and 2017.

Methods

Sample

We analyzed 240 men's matches of a preliminary round from the Olympic Games in 2012 (12OG) and 2016 (16OG) and the World Handball Championship in 2013 (13WHC), 2015 (15WHC) and 2017 (17WHC). All data are based on the official results of the IOC and IHF. We counted the number of shooting plays and goals at each shooting position (6m, wing, 9m, 7m, FB and BT) and the number of technical fouls (TF) and assist plays (AS) during attacking possession. The number of possessions was calculated from sum of shooting plays and TFs.

Analysis

Using these variables, we calculated the ratio of shooting plays and goals against the possessions at each shooting position to make an index of expected shooting play (xS) and expected goal (xG).

Similarly, we made the defending index during opposing possession. Expected received shooting play (xR) and expected conceded goal (xL) were calculated. These variables of xS, xG, xR and xL were the sum of the values at each shooting position, respectively. In addition, expected technical foul (xTF) and expected assist play (xAS) and expected inducing technical foul (xITF) and expected receiving assist play (xRAS) were calculated during attacking possession and opposing possession, respectively. These equations are as follows;

Attacking index
xS = (number of the shooting plays at 6m, wing, 9m, 7m, BT and FB) / number of possessions
xG = (number of the goals at 6m, wing, 9m, 7m, BT and FB) / number of possessions
xTF = number of the technical fouls / number of the possessions
xAS = number of the assist plays / number of the possession

Defending index
xR = (number of the received shooting plays at 6m, wing, 9m, 7m, BT and FB) / number of the opposing possessions
xL = (number of the concerned goals at 6m, wing, 9m, 7m, BT and FB) / number of the opposing possessions
xITF = xTF = number of the inducing technical fouls / number of the opposing possessions
xRAS = number of the opposing assist plays / number of the opposing possessions

Shooting efficiency
Shooting efficiency (%G) and received shooting efficiency (%L) were calculated by dividing xG by xS and xL by xR, respectively. We also calculated the %G and %L at each shooting position, which in turn demonstrated expected goal or expected conceded goal at each shooting position.

In this study, we compared these variables between qualifying (QF) and no qualifying (NQ) groups. The optimum cutoff values of xG and xL for qualification of preliminary round were determined using ROC curve analysis.

Statistics
The descriptive data were presented as the mean and SD for each variable. A two-way analysis of variance (ANOVA) with post hoc comparisons was used to compare the differences among the competitions and between the QF and NQ groups. ROC curve analysis using total xG and total xL were also performed to determine optimum cutoff value for qualification of the preliminary round. Statistical significance was set a priori at $P < 0.05$.

Results & Discussion
The differences among the competitions and between qualifying outcomes
Table 1 showed the xS, xG, %G, xAS and xTF as attacking index and xR, xL, %L, xRAS and xITF as defending index at each competition. As a result of two-way ANOVA, we found the main effects among competitions and between qualifying outcomes in the attacking index of xS, xG, %G, xAS and xTF. No interaction effect was observed between competitions and qualifying outcomes in these variables. From these results, it was demonstrated that these variables of attacking index were varied according to competitions and qualifying outcomes. On the other hand, it was indicated that the competition did not affect the qualifying outcomes because there was no interaction effect between competitions and qualifying outcomes. Thus, the increase of the xS, xG and %G in recent years in both QF and NQ groups were demonstrated regardless of qualifying outcomes. The results of differences between QF and NQ groups in the xS, xG and %G were also independent.

In defending index, the xR was not observed in the main effect among competitions and between qualifying outcomes. The main effect of qualifying outcomes in the xL and %L were observed, but not competitions. The xRAS have the main effects in both competition and qualifying outcomes. Therefore, it was demonstrated that the xR was not changed by competitions nor by qualifying outcomes. The variables of xL and %L were not changed according to the competition, but there were significant differences between qualifying outcomes from 12OG to 17WHC.

The value required of xG and xL for qualification

The values of xG in QF and NQ groups were 0.482±0.086 and 0.367±0.08 in 12OG, 0.495±0.083 and 0.374±0.105 in 13WHC, 0.495±0.066 and 0.397±0.089 in 15WHC, 0.449±0.058 and 0.507±0.075 in 16WHC and 0.511±0.086 and 0.404±0.082 in 17WHC, respectively (Table 1). The mean values of xS and xG in all competitions were 0.807±0.057, 0.498±0.079 in QF group and 0.772±0.067, 0.398±0.084 in NQ group, respectively.

Table 1 Values of xS, xG, %G, xAS and xTF as attacking index and xR, xL, %L, xRAS and xITF as defending index at each competition

	2012 OG LONDON		2013 WHC SPAIN		2015 WHC QATAR		2016 OG RIO		2017 WHC FRANCE				
	NQ	QF	NQ	QF	NQ	QF	NQ	QF	NQ	QF	competitions	qualyfication	interaction
attacking index													
xS	0.768 ± 0.070	0.800 ± 0.053	0.766 ± 0.094	0.814 ± 0.058	0.757 ± 0.066	0.799 ± 0.058	0.787 ± 0.048	0.801 ± 0.055	0.784 ± 0.059	0.823 ± 0.061	0.01	0.01	n.s.
xG	0.367 ± 0.086	0.482 ± 0.086	0.374 ± 0.105	0.495 ± 0.083	0.397 ± 0.089	0.495 ± 0.066	0.449 ± 0.058	0.507 ± 0.075	0.404 ± 0.082	0.511 ± 0.086	0.05	0.01	n.s.
%G	0.478 ± 0.101	0.603 ± 0.092	0.488 ± 0.110	0.608 ± 0.087	0.524 ± 0.103	0.619 ± 0.085	0.570 ± 0.081	0.632 ± 0.095	0.515 ± 0.094	0.621 ± 0.091	0.01	0.01	n.s.
xAS	0.511 ± 0.153	0.513 ± 0.140	0.315 ± 0.145	0.374 ± 0.139	0.508 ± 0.183	0.520 ± 0.138	0.424 ± 0.103	0.439 ± 0.117	0.461 ± 0.168	0.557 ± 0.151	0.01	0.05	n.s.
xTF	0.232 ± 0.070	0.201 ± 0.053	0.234 ± 0.094	0.186 ± 0.058	0.243 ± 0.066	0.201 ± 0.058	0.213 ± 0.048	0.199 ± 0.055	0.219 ± 0.061	0.174 ± 0.057	0.05	0.01	n.s.
defending index													
xR	0.801 ± 0.058	0.783 ± 0.062	0.809 ± 0.083	0.792 ± 0.071	0.790 ± 0.048	0.783 ± 0.071	0.794 ± 0.060	0.798 ± 0.050	0.816 ± 0.065	0.807 ± 0.061	n.s.	n.s.	n.s.
xL	0.503 ± 0.096	0.414 ± 0.091	0.524 ± 0.093	0.420 ± 0.097	0.499 ± 0.080	0.444 ± 0.086	0.495 ± 0.080	0.484 ± 0.072	0.521 ± 0.094	0.452 ± 0.092	n.s.	0.01	0.05
%L	0.628 ± 0.098	0.529 ± 0.104	0.648 ± 0.086	0.530 ± 0.102	0.632 ± 0.098	0.567 ± 0.097	0.623 ± 0.106	0.606 ± 0.089	0.639 ± 0.090	0.560 ± 0.103	n.s.	0.01	0.05
xRAS	0.576 ± 0.142	0.480 ± 0.135	0.421 ± 0.131	0.321 ± 0.138	0.528 ± 0.148	0.510 ± 0.157	0.469 ± 0.126	0.416 ± 0.102	0.572 ± 0.143	0.500 ± 0.168	0.01	0.01	n.s.
xITF	0.199 ± 0.058	0.217 ± 0.062	0.191 ± 0.083	0.208 ± 0.071	0.210 ± 0.048	0.217 ± 0.071	0.206 ± 0.060	0.202 ± 0.050	0.179 ± 0.059	0.194 ± 0.063	0.05	n.s.	n.s.

These values were significantly higher in QF group than in NQ group.In this study, we also calculated the cutoff value of xG needed for qualification in the preliminary round using ROC analysis. The cutoff value of xG was 0.459. Therefore, in both the World Handball Championship and the Olympic Games, the results of ROC analysis demonstrate that values at above the cut off value of xG was 0.459 can qualify for the preliminary round.

In defending index, in QF and NQ groups were 0.414±0.091 and 0.503±0.096 in 12OG, 0.420±0.097 and 0.524±0.093 in 13WHC, 0.444±0.086 and 0.499±0.080 in 15WHC, 484±0.072 and 0.495±0.08 in 16WHC and 0.511±0.086 and 0.404±0.082 in 17WHC, respectively (Table 1). The mean values of xR and xL in all competitions were 0.793±0.063, 0.443±0.088 in QF group and 0.802±0.063, 0.508±0.089 in NQ group, respectively. The cutoff value of xL was 0.473. Therefore, in both WHC and Olympic Games, it is possible to qualify for the preliminary round if the cutoff value of xL is 0.473 or less.

The xS indicates the ratio at which the shooting plays could be performed against possessions. Likewise, the xG indicates an expected goal against possession. The xR and xL of defending index were similar with the attacking index. Thus, we can predict the number of shooting plays and the score using xS and xG and number of possessions. It is possible to predict score distribution between teams before a match because these predicted values can be represented using binomial distribution. The same applies to the defending activity. It is possible to perform this prediction.

The differences of the attacking and defending index between qualifying outcomes

The values of xG and %G in QF group were significantly higher than those in NQ group at each competition. The values of xS and xTF were significant difference between qualifying outcomes in WHCs of 2013, 2015 and 2017, respectively. The difference of value of xAS between qualifying outcomes was observed in 13WHC and 17WHC, respectively.

In WHC, the variables of xS, xG and %G in QF group were higher than those in NQ group. The lowest value of xS in QF group was 0.799±0.058 and the highest values of xS in NQ group were 0.787±0048 in all competitions. In xG, also, the highest value in NQ group and the lowest value was 0.449±0.058 and 0.482±0.086, respectively. These results demonstrated that it is important to maintain high values of xS and xG for qualification and the xS and xG are the indicators related to the qualifying outcomes in the recent Men's World Handball Championship.

In the Olympic Games, the values of xG and %G in QF group were significantly higher than those in NQ group, although there was no significant difference between the qualifying outcomes in xS. These results demonstrated that it is important to maintain high values of shooting efficiency for qualification in Olympic Games.

There were the different results in the attacking index between the World Handball Championship and the Olympics Games. This different result between them is thought to be due to the different number of participating teams. It is thought that the more teams with a lower attacking level were participating in the World Handball Championship than in the Olympic Games because the 12 teams participated in Olympic Games and 24 teams participated in the World Handball Championship.

The values of xL and %L in QF group were significantly lower than those in NQ group, excluding 16OG. The values of xR and xITF were not significantly different between qualifying outcomes in all competitions. The difference of the value of xRAS was observed between qualifying outcomes in 12OG, 13WHC and 17WHC, respectively. The xR and %ITF were not significantly different between qualifying outcomes in all competition. Thus, we speculate that there were similarities in the defending activity in which possession was taken of the opposing team's ball, regardless of qualifying outcomes. On the other hand, it was demonstrated that the defending activities that reduced the shooting efficiency of opposing teams are necessary in order to qualify for the preliminary round because the values of xL and %L in the QF group were significantly lower than those in the NQ group excluding 16OG.

The differences of attacking and defending index between qualifying outcomes at each shooting play position

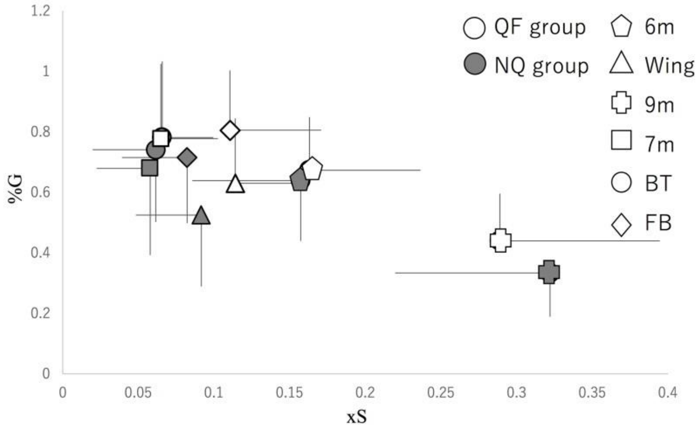

Figure 1 Relationship between xS and %G in QF and NQ groups at each position
The white symbol is the QF group and the black symbol is the NQ group.

Figure 1 shows the relationship between xS and %G in QF and NQ groups at each shooting play position. These values are the averaged values of all competitions. In the 9m shooting play position, the value of xS in the QF group was significantly lower than that of the NQ group. In contrast, the values of xS at Wing, 7m and FB shooting play positions were significantly higher in the QF group than in the NQ group, respectively. The values of %G at each shooting positions in the QF group were 0.673±0.176 in 6m, 0.629±0.215 in Wing, 0.439±0.156 in 9m, 0.781±0.252 in 7m, 0.777±0.247 in BT and 0.806±0.197 in FB; those in the NQ group were 0.639±0.199 in 6m, 0.525±0.236 in Wing, 0.333±0.145 in 9m, 0.679±0.287 in 7m, 0.741±0.239 in BT and 0.715±0.217 in FB, respectively. The values of %G at excluding BT shooting play position were significantly higher in the QF group than in the NQ group. These results indicated that the QF group was taking advantage of the more opportunities to perform the shooting play behaviour at the positions with higher shooting efficiency, compared to the NQ group. In addition, it was observed that the shooting ability was better in the QF group than in the NQ group, excluding BT position.

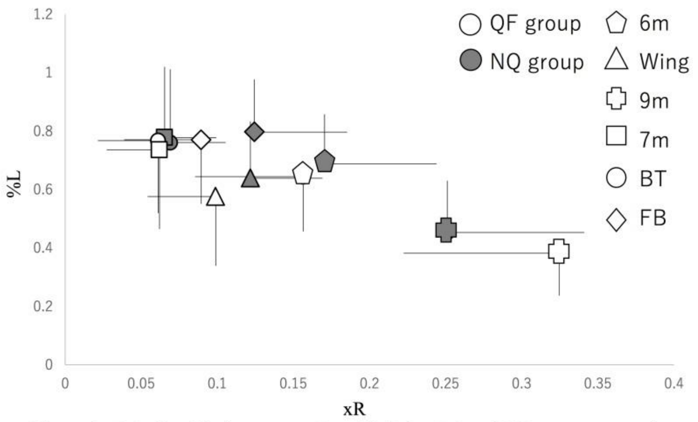

Figure 2 Relationship between xR and %L in QF and NQ groups at each position
The white symbol is the QF group and the black symbol is the NQ group.

Figure 2 shows the relationship between xR and %L in QF and NQ groups at each shooting play position. These values are the averaged values of all competitions. The value of xR in the QF group was significantly lower than that of the NQ group at Wing and FB shooting play positions. In contrast, the value of xR at 9m shooting play position was significantly higher in the QF group than in the NQ group. The value of %L was significantly lower in the QF group than in the NQ group at 6m, Wing, 9m and 7m shooting play positions. From these results, it is thought that the defending activity of QF group was more successfully inhibiting the opposing team from making shooting plays with these positions than the NQ group. In addition, it is thought that the QF group could also perform the defending activities to reduce the opposing shooting efficiency, compared to the NQ group.

The values of %G and %L were not figured into the number of shooting plays. However, the predicted number of goals at each shooting play position are calculated by the variables of the number of possession, xS and %G. The same applies to the defending activity. It is possible to perform this prediction.

Conclusion
We found the required values of the attacking and defending index to qualify for the preliminary round in men's world handball competitions. In this study, the xS, xG and xL in QF group were 0.803±0.057, 0.498±0.079 and 0.443±0.08 and those in NQ group were 0.772±0.067, 0.398±0.084 and 0.508±0.089 in recent men's world handball competitions. These results demonstrate that the attacking and defending behaviors are different between qualifying outcomes. Based on the results of ROC curve analysis, we suggest that currently the values required of xG and xL to qualify for the preliminary round were more than 0.459 in xG and/or less than 0.473 in xL. In addition, we demonstrate that it possible to predict scores using these variables in handball.

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PROVEMENT OF TARGET ACCURACY OF STUDENTS IN CONSIDERATION FOR THE IMPACT ASSESSMENT OF THE „HANDBALL AT SCHOOL" PROJECT

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Introduction

Hungarian Handball Association launched its „Handball at School" project in September 2013 in 50 schools, with 54 PE teachers, 1430 pupils. Thanks to the favourable experience the programme was enlarged in September 2014 to 91 schools and 98 PE teachers, this way growing the number of the children to 3400. At present – due to further enlargement in 2015 – the programme is going on in 117 schools, with 127 PE teachers, with participation of almost 4565 students (1st-8th grades) in 243 groups. Out of all the participants 1435 persons are in 2nd-4th grades. The programme and the schools participating in it have become a dominant scene of talent care besides enlarging youth supply base of handball.

The junior section pupils of the schools (2nd-4th grades) participating in the programme learn basic technical and tactical elements, system of rules of handball sport, twice a week within every-day physical education, and do various ball exercises (to develop skills and dexterity) with light tool (sponge handball) and playful competitions within the lesson and we used control groups. The PE teachers taking part in the education of the programme are trained by the Hungarian Handball Federation and the schools are supplied with the necessary sports equipment. The results are controlled by the mentor system and by surveying the lesson plans sent by the teachers. This programme providing professional supervision, continuous training and check-up as well is exceptional in our country. Although a package and retraining of professionals was ensured in the Hungarian programme of kid-athletics as well, the feedback, the continuous control was not fulfilled as thoroughly as in the school programme of handball, therefore it can be considered unique.

Keywords: handball, every-day physical education, target accuracy, primary school children

Questions and Hypothesis

Before starting our research the following questions were asked. We tried to find the answer to them during our research:

- Which are the tests and procedures to examine the major fitness and coordinating skills that are suitable to help the selection process of junior section pupils in handball sport?
- How will target accuracy of pupils taking part in the survey change due to the project during the year? **Which parameters will mostly have changed** by the autumn and springtime check?
- How will target accuracy, performance stability of students not doing sports and students having different training experience change?

- We consider that tests to check and examine fitness and coordinational skills, sports-specific tests must be approached in a holistic way when finding talents for a sport at junior school age.
- We think that changes in tests between the autumn and spring surveys will mostly occur accordingly with the alternatives of the sport-specific training.
- We presume that students having more hours of training (in any sport) will have better results in the tests in both checks.
- We presume that project „Handball at School" will result in improvements in target accuracy tasks at students not doing sport (past training 0 year) and the ones doing sport, after half a year proving favourable benefits of the programme.

Materials and Methods

Our survey was organised in three schools in autumn and spring, 2015. Primary school children of 2nd and 4th grades having 5 PE lessons a week out of which 2 lessons were spent on acquiring the knowledge of handball sport. They were surveyed in Budapest, Tomori Pál primary school, in Ajka, Fekete-Vörösmarty primary school, and in Gyöngyös, Kálváriaparti primary school. These schools joined the programme on 1st September 2013, the teachers are well-trained professionals, PE teachers having big experience in teaching handball as well. We chose the control group (n=110) from Tiszafüred and Eger primary school children of 2nd and 4th grades who are having 5 PE lessons a week.

We aimed to analyse the 10% of the sample. Out of 1430 pupils of the junior section 183 took part in the survey, that is 12.8% of them. The locations were chosen so that from Western- and Eastern Hungary and a school from the capital city were in the sample, so all the regions of Hungary were represented.

Table 1. Sporting habits of the experimental sample

		Measured children (person)	**Measured children (%)**
Experimental group	Does not do sport	44	24.0
	Handball	44	24.0
	Other sport	95	51.9
	Total	**183**	**100.0**
Control group	Does not do sport	78	70.9
	Does sport	32	29.1
	Total	**110**	**100.0**

Therefore the description of these tests and their evaluation is also shown in details:

1. **Shooting in transversal straddle position without running up** (to survey sport specific coordination skills)

The pupils stood behind the line on the floor, 5 spongehandballs adequate to their age were placed in a turned-up small box on the side of their throwing hand (see test 2). A small box (dimension: 26 cm tall, 62 cm long, 42 cm wide) was placed 5.5 meters away in case of 1st-2nd class children, and 6 meters away in case of 3rd-4th class pupils in the way that the surface covered in leather, faced the pupil performing the shot. The pupil – having heard the whistle- had to aim at the surface of the small box with the balls having taken from the small box near him so that the ball hit it with a direct touch. It was performed with upper throw.

The number of attempts were 5, at the survey the number of scores, the time of implementation (with digital watch, sec. – centi-seconds accuracy) were taken and accuracy index was counted (average/deviation).

2. **Shooting in transversal straddle position with running up** (to survey sport specific coordination skills)

The pupils stood behind the line on the floor, (The distance of the line and the target surface was the same as in test 5). 5 spongehandballs adequate to their age were placed in a turned-upsmall box on the side of their throwing hand (see test 2) The pupil – having heard the whistle- had to run back to the small box and, taking a ball out of it had to run to the line and similarly to task 5, had to aim at the small box. He had to repeat it as long as he used all the 5 balls. It was performed with upper throw.

The number of attempts were 5, at measuring the number of scores, the time of implementation (with digital watch, sec. – centi-seconds accuracy) were taken and accuracy index was counted (average/deviation).

The way of calculation:
The results of the trials applied in the survey were expressed in a quantitative way as well. The data were processed with SPSS.22.0 statistical programme. The results were processed and evaluated following mathematical basic statistics survey procedures.
Based on the instructions of the handbook: „Introduction to the Methodology of Scientific Research" the population was grouped, then average and deviation values, median and modus were counted with basic statistic methods. The correlation survey was done with a two-sample T-test to show the difference between the groups or difference between the autumn- and spring values.
We compared control and experimental group with an independent samples test.

The test checking target accuracy without running up is not exactly sport-specific.
The „Handball at School" project unquestionably had positive effects on the performance of all the four groups.
During the first trial the students performed 5 throws, which were repeated after some rest (2nd trial). As it can be seen in the table, when focusing on the different training periods, that both in the first and second trial in the non-sporting group and in the case of those doing sport for 1 year the programme of the handball lesson improved the target accuracy (the spring results systematically showed better results compared to the autumn ones, since significant differences could be measured). The target accuracy of those having been going to trainings for two-three years is above the first two groups, shown by the higher score results. The target accuracy of those having been going to trainings for two-three years is merely tendencious, as the values of the Paired Samples T-tests do not show significant results.

Concerning the accuracy of technical implementation (the elbow is lifted while throwing) it can be stated that the accuracy of implementation has got better from autumn to spring both at students not doing sports and at the group of the ones having been doing sports for one and two years which can be seen by the improving average figures of scoring and lower deviation figures (stability of performance has got better, proven by the smaller range of variations), the two-trial T-tests resulted in significant difference between the autumn and spring measures. In the case of the students having been doing trainings for three years no significant improvement in technical implementation was experienced.

As for the time results of the implementation it can be declared that the speed component has improved both at students not doing sports and at the group of the ones having been doing sports for one and two years from autumn to spring, proven by the significant values. In the case of the students having been doing trainings for three years, improvement in time can only be seen in its tendency.

Table 3. The results of shooting in transversal straddle position without running up related to control group

	Control group n=110			
	Autumn result		Spring result	
	mean	deviation	mean	deviation
First trial Scores	0,61	0,72	0,52	0,70
Second trial Scores	0,74	0,75	0,50	0,70
First trial Lifted elbow	0,53	0,67	0,70	0,76
Second trial Lifted elbow	0,59	0,68	0,69	0,71
First trial Time (sec)	15,70**	2,11**	15,40**	1,79**
Second trial Time (sec)	15,68**	1,87**	15,12**	1,84**

(* significant $p<0.05$ ** very significant $p<0.01$, showing the change in performance in the surveyed group from autumn to spring)

The figures of the chart show that the control group (non-sponge handballers) does not show significant improvement either in score results (target security) or in technical implementation of throwing from autumn to spring. Improvement of time results could be proven, which is thanks to development, aging and daily physical education lessons.

The control group has produced worse results both in score results, level of technical implementation (keeping elbow lifted) and time results of the implementation than the check-group of sponge handballers. The difference is big in all the three cases (p=0,000).

This trial needs sports-specific skills and contains elements characteristic of handball more dominantly.

The score results of shooting with running up trial show lower values in all the four groups. Focusing on the target, scoring combined with running up proved to be more complicated, since this sports specific trial needs a higher level of coordination skills, like measuring distance, time speed and sense of direction.

Target accuracy of the first and second trial has shown improvement in all the four groups from autumn to spring, however, significant improvement was seen only in the group having 1 year training experience, in the other groups only a tendency was experienced.

Evaluating the accuracy of technical implementation (elbow is lifted when throwing) it can be stated that it improved in all the four groups, from autumn to spring, which can be seen by the improving average figures of scoring and lower deviation figures (stability of performance got better, proven by the smaller range of variations), the two-trial T-tests resulted in significant difference between the autumn and spring measures.

Time results show improvement tendency in all the examined groups (exception is the second trial of students having 3 years of sports experience).

The favourable effect of the project is proven by sport-specific tests as well, in the case of all the four groups, since the changes between the autumn and spring surveys always showed significant improvement (an exception is the change in scoring accuracy of the non-sporting group and the one having been doing sports for three years).

Table 5. The results of shooting with running up T-test related to control group

	Control group n=110			
	Autumn result		Spring result	
	mean	deviation	mean	deviation
First trial Scores	0,51	0,62	0,63	0,73
Second trial Scores	0,50	0,65	0,49	0,69
First trial Lifted elbow	0,48	0,62	0,88	0,85
Second trial Lifted elbow	0,81	0,78	0,61	0,74
First trial Time (sec)	20,70**	1,78**	20,48**	1,84**
Second trial Time (sec)	20,46**	1,72**	20,35**	1,68**

(* significant $p<0.05$ ** very significant $p<0.01$, showing the change in performance in the surveyed group from autumn to spring)

The test measuring target security from run-up is the one which mostly reflects specifics of handball sport when checking output. This test proves effects of sponge handball on the check-group. Similarly to the results of the test done without run-up it was experienced here as well that in shooting results and technical implementation of the throw there was only tendency on improvement from autumn to spring. The improvement of time results could be detected at this test as well.

Both target security, technical implementation and time results have resulted in significantly bigger (p=0,000) improvement in the test group than in the control group proving the positive effects of sponge handball in the sport specific test.

Conclusion

During our pilot research it was experienced that in small school age tests checking fitness and coordination skills, tests sport-specific to handball must be treated in a complex, holistic way when finding talents for choosing a sport.

The „Handball at School" project – involving two sport-specific lessons a week – improved shooting accuracy and speed coordination abilities of all the children.

The „Handball at School" project showed improvement in all the four examined groups, after half a year, since the two sample T-test results of the autumn and spring, proved significant improvement in the particular fields. It was stated in our previous article that the best results were achieved by those playing handball, then the ones doing another sport, while target scoring accuracy and performance constancy was lower of those not doing any sport apart from PE lessons.

Table 2. The results of shooting in transversal straddle position without running up related to the experimental group

	0 year training n=65				**1-year training n=74**				**2-year training n=29**				**3-year training n=15**			
	Autumn result		Spring result		Autumn result		Spring result		Autumn result		Spring result		Autumn result		Spring results	
	mean	deviation	mean	deviation	mean	deviation	mean	deviation	mean	deviation	mean	deviation	mean	deviation	mean	deviation
First trial Scores	1.11**	1.09**	1..68**	1.30**	1.45**	1.31**	2.09**	1.33**	1.41	1.05	2.28	1.19	1.87	1.41	1.80	1.42
Second trial Scores	1.29**	1.13**	1.46**	1.11**	1.49**	1.16**	2.42**	1.35**	1.59	1.35	2.00	1.00	1.47	1.30	1.73	1.16
First trial Lifted elbow	3.03**	2.02**	3.54**	1.72**	3.30**	1.82**	4.01**	1.49**	3.69**	1.91**	4.17**	1.42**	3.60	1.92	3.20	1.74
Second trial Lifted elbow	3.12**	1.81**	3.68**	1.68**	3.38**	1.85**	3.98**	1.46**	3.59*	2.03*	4.31*	1.31*	3.47	1.73	3.33	1.68
First trial Time (sec)	11.69**	2.58**	10.64**	2.21**	11.61**	1.88**	11.23**	1.94**	11.36**	2.32**	10.33**	1.46**	11.19	1.88	9.96	1.61
Second trial Time (sec)	11.25**	2.31**	10.10**	2.15**	11.52**	2.04**	10.67**	2.08**	10.28**	2.12**	9.87**	1.65**	10.34	1.51	10.00	1.36

(* significant p<0.05 ** very significant p<0.01, showing the change in performance in the surveyed group from autumn to spring

Table 4. The results of shooting with running up T-test related to years spent on training

	0 year training n=65				**1-year training n=74**				**2-year training n=29**				**3-year training n=15**			
	Autumn result		Spring result		Autumn result		Spring result		Autumn result		Spring result		Autumn result		Spring result	
	mean	deviation	mean	deviation	mean	deviation	mean	deviation	mean	deviation	mean	deviation	mean	deviation	mean	deviation
First trial Scores	1.11	1.05	1.57	1.08	1.49**	1.10**	2.38**	1.51**	1.21	1.26	1.72	1.44	1.00	0.93	1.67	0.98
Second trial Scores	1.23	1.17	1.57	1.15	1.46**	1.13**	2.22**	1.36**	1.55	1.09	1.90	1.47	1.33	0.90	1.73	1.03
First trial Lifted elbow	2.95**	1.95**	3.95**	1.59**	3.22**	1.91**	3.69**	1.68**	3.62**	2.11**	3.90**	1.66**	2.47**	2.50**	3.00**	2.07**
Second trial Lifted elbow	3.14**	1.86**	3.80**	1.68**	3.41**	1.90**	3.84**	1.41**	3.66**	1.93**	3.79**	1.80**	2.53*	2.00*	3.27*	1.83*
First trial Time (sec)	18.56**	3.21**	17.84**	3.40**	18.88**	2.86**	17.97**	2.81**	16.90**	2.91**	16.19**	1.89**	16.79*	1.60*	16.48*	1.78*
Second trial Time (sec)	18.43**	3.20**	17.64**	3.64**	18.38**	2.54**	18.19**	2.71**	16.92*	2.33*	16.62*	2.18*	16.19	1.40	16.95	1.48

(* significant p<0.05 ** very significant p<0.01, showing the change in performance in the surveyed group from autumn to spring

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IS THE LEVEL OF ANTHROPOMETRIC AND PERFORMANCE REQUIREMENTS LOWER FOR LEFT-HANDED PLAYERS IN YOUNG ELITE HANDBALL PLAYERS?

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Summary
Anthropometric profile and physical performance are playing-position dependent, but few studies were done with young players and none had considered handedness. Therefore, the aims of this research were to measure the differences and the relations between physical performances, body dimensions and maturity of young players regarding their playing positions and handedness. 134 young players (13.9±0.3 years) selected from five handball leagues in France from 2012 to 2014 participated in this study. Standing height, sitting height and body mass were measured and we calculated peak height velocity (PHV). All players performed three 10, three 30 meters sprints and three counter movement jumps. We recorded the best performance of each test. Pivots were moderately to very largely heavier (ES=1-2.6) than the other players. Backs (left and right), goalkeepers and pivots were moderately to very largely taller than the other players (ES=1.1-2.5). Pivots were up to very largely more mature than the other players (ES=1.1-3.1). Wings (left and right) and left backs ran slightly to moderately faster than right backs and center backs (ES=0.2-1) and largely to very largely faster than pivots and goalkeepers (ES=0.7-1.5). Left wings jumped slightly to very largely higher than the other players. Correlations were moderate to very large (r=0.43 to 0.86) between body dimensions and maturity for all playing position. Body mass and height were not related for pivots (r=-0.07) compared to the other players (r=0.48 to 0.78). Relationship between sprint test (10m and 30m) and CMJs were moderate to very large for all playing position (r=0.36-0.79) except for goalkeeper (r=0.5 to 0.52) and for left wings (CMJ were not related to sprint tests (r=-0.23 and 0.15). Anthropometric and physical profile are playing-position dependent and are also influenced by handedness. Coaches should consider the specific playing position context in talent identification.

Keywords: talent, elite, handball, testing, CMJ

Introduction

In France, the number of players has increased (270 000 players in 2000, >500 000 today) with the number of international titles (23 medals) (Wikipedia, 2017a). International successes contribute largely to increase the number of handball players in France (Wikipedia, 2017b). Winning medals is therefore a major development issue for national federations. Handball is a strenuous contact team sport. Players need to perform many explosive actions such as sprints, jumps and changes of direction. Game demands are largely influenced by playing positions which affect the players' profile (C. Karcher & Buchheit, 2014). Pivots are the heavier and wings players are the lightest (C. Karcher, Hamaidi, & Buchheit, 2014). Back players, pivots and goalkeepers are the tallest (C. Karcher et al., 2014; Massuca, Fragoso, & Teles, 2014; Schwesig et al., 2017) but we need more result to have a better understanding of the anthropological profile needed for the elite level. There are some differences in the performance profile between playing positions, but they are still unclear. For example, Krüger et al. (Kruger, Pilat, Uckert, Frech, & Mooren, 2014) have found that wings players jump higher than the other players when it was goalkeepers in Michalsik et al. (Michalsik, 2011). For sprints, even if it seems that wings players are the fastest, there aren't any consensus for the others playing positions (Chaouachi et al., 2009; Kruger et al., 2014; Michalsik LB, 2011). Moreover, there were in most of the studies very few statistical differences and mostly no differences at all between playing positions. In the context of talent identification, it is important to note that the maturity process could influence performance results (Buchheit & Mendez-Villanueva, 2014; Deprez et al., 2015) and that there is some maturity difference between playing positions (Matthys, Fransen, Vaeyens, Lenoir, & Philippaerts, 2013). The few studies that have considered playing positions have merged some positions together (e.g., lateral backs and center backs (Chaouachi et al., 2009). Another limitation of the literature is that handedness was not considered. In elite team there are at least 4 left handed players (2 backs and 2 wings) that represent about 25% of a handball team when there are only about 10% in the French population (Raymond & Pontier, 2004). Moreover, right backs measure on average more than 190cm (Kruger et al., 2014) when the average height in France is 175cm (Roser, 2017). The likelihood of being lefthanded and taller than 190cm seems to be very low in France. The aim of this study was to measure (1) differences between playing positions and (2) between left and right-handed players in the anthropometric, maturity and performance profile.

Methods

We have tested 134 young male handball players (13.9±0.3 years) with 5.2±0.6 years of playing experience during 3 seasons. Players were selected from 5 regions of France before entering a regional youth academy. We classified all the players related to their playing positions (Left wing, left back, center back, pivot, right back, right wing and goalkeeper). We measured height and weight of all the players and we estimate their maturity with the Mirwald's equation (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002). Speed and lower body power were evaluated with 10 and 30-meter sprints and a counter movement jump with arms (CMJ). Data are presented as means and standard deviations. We used the Hopkins' approach with standardized difference of the mean (Hopkins, Marshall, Batterham, & Hanin, 2009). We analyzed these differences for practical significance using a magnitude based approach and we report only at least very likely differences. We used Pearson's correlation to investigate relationships between each variable. We use Hopkins scale to interpret the degree of correlation (Hopkins et al., 2009). If the 90% confidence interval overlapped small and negative values, correlation coefficient was deemed as unclear.

Results

The results of the tests are shown in figure 1. Wings (left and right) were up to largely smaller than the other players (ES from 0.76 to 2.51) and lateral backs were moderately taller than center backs (0.88 to 1.14). Pivots were heavier (ES from 1.01 to 2.63) and center backs were moderately lighter than lateral backs (ES from 0.8 to 1.15). Pivots were moderately to very largely more mature than their peers (ES from 0.8 to 3.1). In the sprints (10m and 30m), goalkeepers and pivots were up to moderately slower than the other players and wings (left and right) were the fastest (10m sprint ES from 0.2 to 1.03, 30m sprint ES from 0.73 to 1.54). Left wings jumped largely higher than right wings (ES=0.85) and moderately to very largely higher than the other players (ES from 0.65 to 1.85).

Correlations and 90% confidence intervals between all the results are shown in table 1. Correlation between weight and maturity ranged from 0.43 to 0.86, between height and maturity from 0.38 to 0.82 and between height and weight from 0.07 to 0.78. Pivots were the position with the weakest relations (height-weight (0.07), weight and maturity (0.43) and height and maturity (0.38)). The relation between 10 and 30m sprints were very large (0.74-0.86) excepted for goalkeepers (0.51). There were no relations between sprint tests (10m and 30m sprints) and CMJ for the left wings (for 10m-CMJ, r=0.15 and for 30m-CMJ, r=-0.2) and a moderate relation for the left backs (10m-CMJ=0.36 and 30M-CMJ=0.43). For the other playing positions, the coefficient correlation ranged from large to very large (0.52 to 0.79).

Poste	Height-Weight		Height-PHV		Weight-PHV		10m-30m		10m-CMJ		30m-CMJ	
RW	**0,78**		**0,86**		**0,82**		**0,81**		**-0,71**		**-0,78**	
	0,59	*0,97*	*0,73*	*0,99*	*0,65*	*0,98*	*0,65*	*0,98*	*-0,94*	*-0,48*	*-0,97*	*-0,59*
LW	**0,58**		**0,82**		**0,45**		**0,74**		**0,15**		**-0,23**	
	0,27	*0,9*	*0,65*	*0,99*	*0,09*	*0,82*	*0,51*	*0,96*	*-0,29*	*0,58*	*-0,65*	*0,2*
RB	**0,51**		**0,59**		**0,61**		**0,78**		**-0,45**		**-0,61**	
	0,24	*0,79*	*0,34*	*0,84*	*0,37*	*0,85*	*0,62*	*0,93*	*-0,75*	*-0,16*	*-0,85*	*-0,37*
LB	**0,48**		**0,8**		**0,43**		**0,86**		**-0,36**		**-0,43**	
	0,18	*0,77*	*0,65*	*0,94*	*0,12*	*0,74*	*0,75*	*0,97*	*-0,69*	*-0,03*	*-0,74*	*-0,13*
CB	**0,55**		**0,71**		**0,81**		**0,85**		**-0,56**		**-0,52**	
	0,26	*0,85*	*0,5*	*0,93*	*0,65*	*0,96*	*0,72*	*0,98*	*-0,85*	*-0,27*	*-0,83*	*-0,21*
GK	**0,49**		**0,74**		**0,71**		**0,51**		**-0,57**		**-0,67**	
	0,16	*0,83*	*0,53*	*0,96*	*0,47*	*0,94*	*0,18*	*0,84*	*-0,88*	*-0,27*	*-0,93*	*-0,42*
PIV	**-0,07**		**0,43**		**0,38**		**0,86**		**-0,79**		**-0,77**	
	-0,42	*0,27*	*0,15*	*0,72*	*0,09*	*0,68*	*0,77*	*0,96*	*-0,93*	*-0,65*	*-0,92*	*-0,62*

Table 1: Pearson correlation coefficients between anthropometrics and performance results with respect of the playing positions. Italicized numbers are the lower/upper limits of the confidence interval. RW stands for right wings, LW for left wing, RB for right back, LB for left back, CB for center back, GK for goalkeeper, PIV for pivot

Discussion

The main findings of this study are that pivots have a specific anthropometric profile, are more mature than the other players and that left wings jump higher than the other players. Players are already playing-position-profiled to meet the anthropometrics requirements. Lateral backs (left and right), goalkeepers and pivots positions are held by the tallest players, the wing positions (left and right) by the smallest and center backs lie between these two groups. It is important to consider each playing position while we have found moderate differences in the height between center backs and lateral backs (left and right). Our results are in-line with a previous study even if the body dimensions are reduced, the between playing-position differences are the same (C. Karcher et al., 2014). The specific profile of the pivots and our results confirmed the influence of the playing position in handball and emphasize the fact that game demands largely influence players profiles. Trainers are looking for position-profiled players even in the first step of the talent identification process.

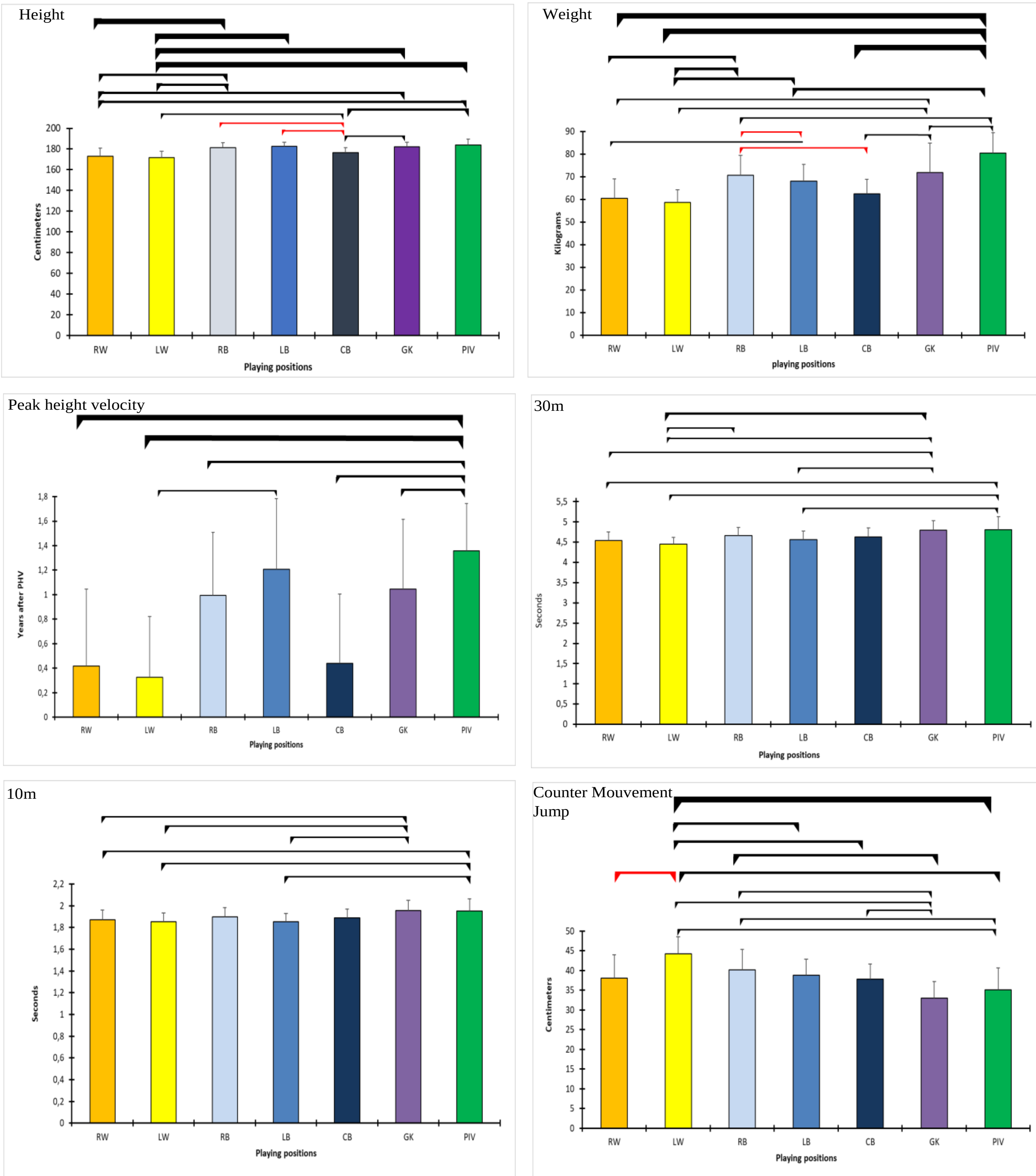

Figure 1: Mean (SD) value in the different variable with respect of playing positions. RW for right wings, LW for left-wings, RB for right-backs, LB for left-backs, CB for center-backs, GK for goalkeeper, PIV for pivots. Line thickness represent the magnitude of the difference between two playing-positions. Large lines stand for a very large difference, medium lines for large difference and the thinners lines for moderate difference.

Sprint tests results are in line with previous studies (C. Karcher et al., 2014). The most interesting finding is that left wings jump higher than all the other players. We can think that coaches have more choice in the left wings positions because there are any anthropometric or handedness requirements (C. Karcher et al., 2014). Coaches can be more demanding for right-handed players because they have more choice to select players but less demanding with left-handed players. For example, in France there only about 10% of the population that are left-handed (Raymond & Pontier, 2004). Young left-handed people taller than 190cm are therefore very scarce in France. Thus, coaches can apply their ideal profile related to the level of anthropometrics and handedness requirements. It is paramount to challenge the trainers' beliefs. For example, a study has shown that flight time is not related to efficiency in wing shots and that CMJ and flight time in wings shots are not related (Karcher , Hamaidi, & Buchheit, 2013). Coaches must also consider that the level of requirements may be higher for right-handed players. They are more exposed to relative age effect (Karcher et al., 2013), they have to be taller and heavier and more athletic than left-handed players (C. Karcher et al., 2014). Limitations of our study are that we did not use any aerobic test and only one jump test. These results could have confirmed the athletic superiority of the right-handed players. Our results are only valid for the French federation because France have a lot of players compared to other countries (>700 000, (Wikipedia, 2017b). Our findings may be restricted to the region considered (north east of France) as the context (demographic and trainers beliefs) could be different in other parts of France. However, our study highlights that it is paramount to consider the playing position in talent identification in handball and that coaches beliefs may affect differently the process depending on the playing position context.

Practical applications

In conclusion, we provide the level of anthropometric and performance requirements in the decreasing order for each playing position: left wing, center back, left back, goalkeeper, right wing, right back.

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FASTER PERCEPTION, FASTER AND MORE ACCURATE DECISION-MAKING, FASTER ACTIONS – THE FUTURE OF SUCCESSFUL HANDBALL. SPEEDCOURT: A REVOLUTIONARY AND HIGHLY EFFECTIVE SYSTEM FOR ANALYSIS, ATHLETE PROFILING, AND EFFECTIVE TRAINING.

Lutz LANDGRAF
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Summary
Reactive agility – a decisive prerequisite for a successful playing behaviour. Theoretical examination and empirical analysis of time sequences in game situations prove the significance. SpeedCourt is an innovative measuring, information, and training system especially developed for the measurement and improvement of reactive agility. Extensive experiences with practical application of the SpeedCourt show that all components of reactive agility can be trained and improved.

Background

"Handball is getting faster and faster" – an often-repeated assessment. The faster play is characterised by extremely fast changing game situations in offensive and defensive play as well as a higher passing speed.
Regardless of technique, tactic, and fitness, if an athlete is lacking in reactive agility, they may never perform to their full ability. Players who want to be successful in a game need a head start – a successful, individual, and cooperative performance requires faster as well as more accurate perception, decision-making, and action.
The process of perceiving and solving a situation takes place within one or two seconds – with individual components i.e. perceiving a game situation need to occur within 0.1 to 0.3 seconds. Figures 1 and 2 show explicitly the narrow time frame given for perceiving the game situation, making a decision, and taking action.

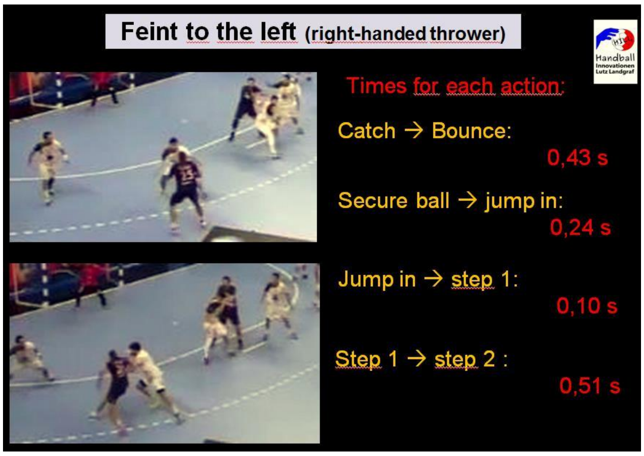


Figure 1

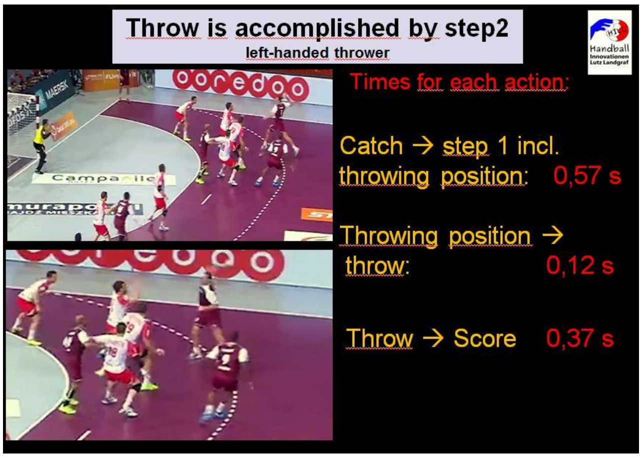


Figure 2

Studies have shown that 70 to 80 % of time needed for technotactical tasks is taken up by mental speed (Friedrich, 2016). This time too can be significantly shortened by specifically training information intake and processing.
Based on these facts, it seems appropriate to reassess the proportions of key aspects of the training.

Reactive agility

"Ability to react as fast as possible in a game situation including complex cognitive, techno-tactical,and conditional requirements." (modified according to Schlimper, 1989). The complexity can also be seen in the overview of components of reactive agility (fig. 3 and 4). Conditional,

motoric and technotactical components have been studied intensively, we believe that in future, cognitive components will play a deciding role for improvements in performance (see fig. 4).
Our hypothesis: improving reactive agility is not only an integral part of the training but also the key to a successful game.

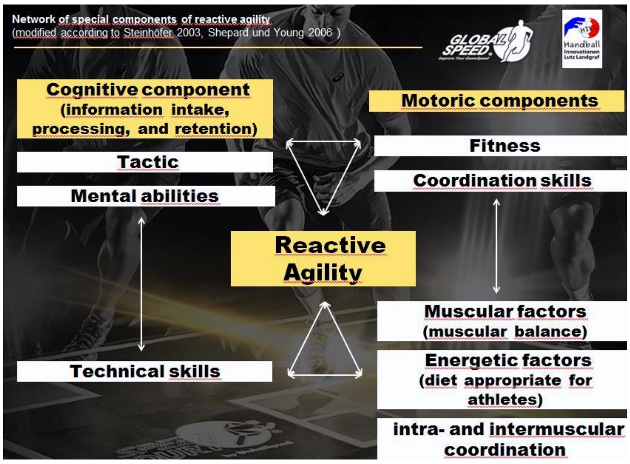


Figure 3

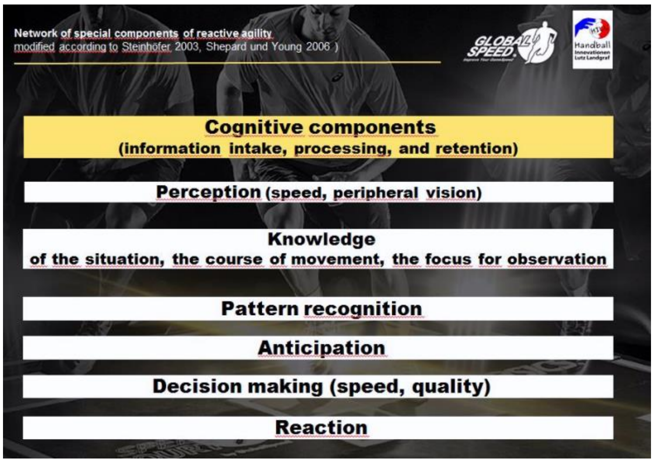


Figure 4

We would like to point out, that achieving a goal-orientated, successful improvement of all components is only feasible with efficient information processing, in which special attention should be paid to permanent information retention during daily training processes. The coach can monitor the efficacy of this process only by permanent feedback from the athletes themselves. At the same time, subliminal factors (experience images), which can be crucial for reactive agility in a team's nonverbal communication system, should also be considered.
Following quote underlines our view: „In the future, we should focus on improving cognitive Skills" (Groß, 2013).
Our experience with around 1000 athletes shows that all components of reactive agility can be trained and improved. Here, setting individual priorities for the selection of components and their differentiation or in complex training is necessary.

Diagnostics and training with Speed-Court

Success in the game and the improvement of individual components is determined in the space of fractions of a second. In order to gain a meaningful diagnosis, effective control of the training, and to choose individual core areas, special methods for analysis and training are necessary.
Speed-Court is a revolutionary and flexible system living up to these demands.

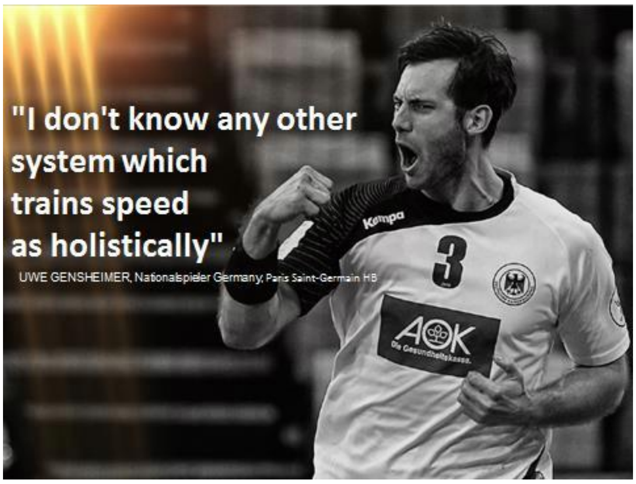


Figure 5

The system
Speed-Court was developed for the diagnosis and training of reactive agility.
Its size and structure can be adjusted according to the needs of the specific sport. For this study, Speed-Courts of the dimensions 4x4 m and 5.5x5.5 m were used. Within the surface for measurement and training of 16 m² and 27.5 m² respectively, twelve sensors with an active area of 0.5x0.5 m were integrated (see Fig. 6 for detailed structure). By means of tactile sensors standard parameters such as tapping frequency and jump height as well as more complex ones, i.e. turning time, contact time, reaction time, and running speed. The data collection accuracy is 1/1000th of a second. A monitor positioned at the front side of the training surface acts as a stimulus (see Fig. 6 and 7).

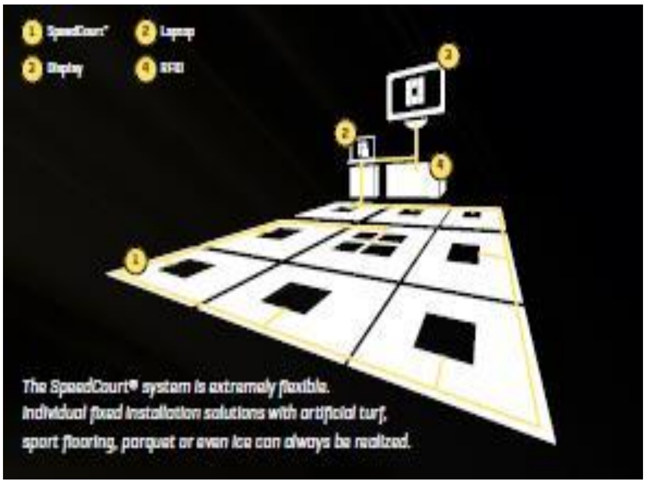


Figure 6

Figure 7

The software is equipped with a wide range of prewritten exercises. Additionally, new exercises or variations for specific tasks can be generated by the user. Combining exercises is possible as well. Therefore, scenarios for training and assessment of both individual components and complex reactive agility can be created and executed. Moreover, conventional exercises for agility (sequence with preplanned change of direction) and exercises for reactive agility (sequence with random – reactive change of direction) are possible.
The Speeds-Court's requirements can be characterised as semi-specific. Individual factors as well as the whole complex can be assessed in detail. Cognitive components play a central role here since it is possible to show these components transparently for the first time.
The system provides a instant output (measured values) including a ranking of achievements in the current exercise and the personal development. Herein lies another reason for the effectiveness of the SpeedCourt. The instant displaying of results highly motivates the athletes and initiates a cognitive process for task and movement perception.
An RFID chip permits using the system in absence of a coach and assigning data to specific athletes.

Levels of application, facilities, studies
The SpeedCourt has proved its worth as a measuring, information, and training system in various applications internationally since 2010, as has been shown by a growing number of studies.

- In competitive sports, especially football
- In Olympia training centres
- Talent development and promotion programmes
- In scientific studies of athletic performance (universities)
- In medical and rehabilitation institutions
- In Sports schools and hotels
- In fitness and fun areas at certain events

In addition, the SpeedCourt can be deployed as a portable device for analysis, studies, and training.

Figure 8

Figure 9

Selected papers on the use of SpeedCourts:

- Fast Response Training in Youth Soccer Players (Bartels, Proeger, Meyer, Brehme, Pyschik, Delank. Fieseler, Schulze, Schwesig – 2016)
- Multi-Directional Sprint Training Improves Change-Of-Direction Speed and Reactive Agility in Young Highly Trained Soccer Players (Born, Zinner, Düking, Sperlich – 2016)
- The SpeedCourt system in rehabilitation after reconstruction surgery of the anterior cruciate ligament/ ACL (Bartels, Proeger, Brehme, Pyschik, Delank, Schulze, Schwesig, Fieseler – 2016)
- Relationship Between Reactive Agility and Change of Direction Speed in Amateur Soccer Players (Matlák, Tihanyi, Rácz – 2016)
- The SpeedCourt: Reliability, Usefulness and Validity of a New Method to Determine Change-of-Direction Speed (Düking, Born, Sperlich – 2016)

SpeedCourt in Action

Figure 10: In competitive sports – Football – FC Bayern München

Figure 11: Youth competitive sports (DHB)

Figure 12: Rehabilitation and prevention (Bayer 04)

Figure 13: At events

Results, Athlete Profiling

A goal-orientated and effective training necessitates an objective and transparent planning with integrated comparisons of target and actual performance. Based on theoretical assumptions we have compiled a battery of basic exercises.

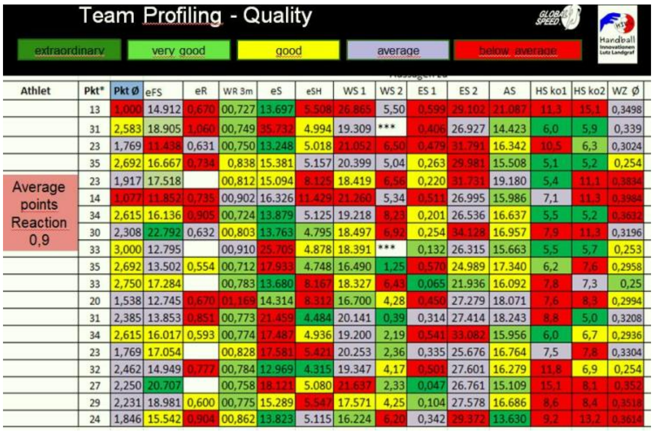
Results of SpeedCourt exercises of female youth national teams in Germany can be evaluated by way of example. Based on the exercises we deduce the skill level of following components:

- Elementary frequency
- Reactive agility (hand to foot), distinguishing between left and right
- Speed of perception
- Speed of decision-making
- Requirements for anticipation
- Complex cognitive skills
- Change of direction speed, distinguished between left and right
- Linear speed performance
- Ground contact time and flight time, jump height (drop jump and counter movement)

Based on our measured data we categorised the results exploratively according to a five-step scale, the individual scores are highlighted in different colours in the following figures.

extraordinary 5 points	very good 4 points	Good 3 points	Average 1 point	below average 0 points

To facilitate an easy comparison of athletes and a global grading of the levels of reactive agility we assigned a certain number of points to each quality step. The average of points permits a ranking of reactive agility of individual athletes within a team and globally (Figure 14 and 15).

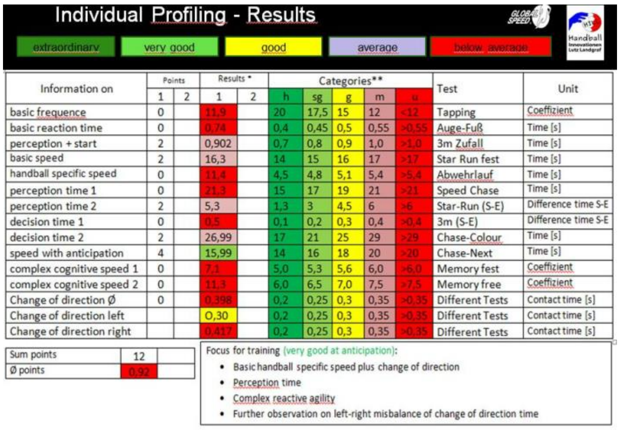


Team Profiling - Quality

extraordinary | very good | good | average | below average

Athlet	Pkt*	Pkt Ø	eFS	eR	WR 3m	eS	eSH	WS 1	WS 2	ES 1	ES 2	AS	HS ko1	HS ko2	WZ Ø
	13	1,000	14.912	0,670	00,727	13.697	5.508	26.865	5,50	0,599	29.102	21.087	11,3	15,1	0,3498
	31	2,583	18.905	1,060	00,749	35.732	4.994	19.309	***	0,406	26.927	14.423	6,0	5,9	0,339
	23	1,769	11.438	0,631	00,750	13.248	5.018	21.052	6,50	0,479	31.791	16.342	10,5	6,3	0,3024
	35	2,692	16.667	0,734	0,838	15.381	5.157	20.399	5,04	0,263	29.981	15.508	5,1	5,2	0,254
Average points Reaction 0,9	23	1,917	17.518		00,812	15.094	8.125	18.419	6,56	0,220	31.731	19.180	5,4	11,1	0,3834
	14	1,077	11.852	0,735	00,902	16.326	11.429	21.260	5,34	0,511	26.995	15.986	7,1	11,3	0,3984
	34	2,615	16.136	0,905	00,724	13.879	5.125	19.218	8,23	0,201	26.536	16.637	5,5	5,2	0,3632
	30	2,308	22.792	0,632	00,803	13.763	4.795	18.497	6,92	0,254	34.128	16.957	7,9	11,3	0,3196
	33	3,000	12.795		00,910	25.705	4.878	18.391	***	0,132	26.315	15.663	5,5	5,7	0,253
	35	2,692	13.502	0,554	00,712	17.933	4.748	16.490	1,25	0,570	24.989	17.340	6,2	7,6	0,2958
	33	2,750	17.284		00,783	13.680	8.167	18.327	6,43	0,065	21.936	16.092	7,8	7,3	0,25
	20	1,538	12.745	0,670	01,169	14.314	8.312	16.700	4,28	0,450	27.279	18.071	7,6	8,3	0,2994
	31	2,385	13.853	0,851	00,773	21.459	4.484	20.141	0,39	0,314	27.414	18.243	8,8	5,0	0,3208
	34	2,615	16.017	0,593	00,774	17.487	4.936	19.200	2,19	0,541	33.082	15.956	6,0	6,7	0,2936
	23	1,769	17.054		00,828	17.581	5.421	20.253	2,36	0,335	25.676	16.764	7,5	7,8	0,3304
	32	2,462	14.949	0,777	00,784	12.969	4.315	19.347	4,17	0,501	27.601	16.279	11,8	6,9	0,254
	27	2,250	20.707		00,758	18.121	5.080	21.637	2,33	0,047	26.761	15.109	15,1	8,1	0,352
	29	2,231	18.981	0,600	00,775	15.289	5.547	17.571	4,25	0,104	27.578	16.686	8,6	8,4	0,3518
	24	1,846	15.542	0,904	00,862	13.823	5.115	16.224	6,20	0,342	29.372	13.630	9,2	13,2	0,3614

Figure 14



Individual Profiling - Results

extraordinary | very good | good | average | below average

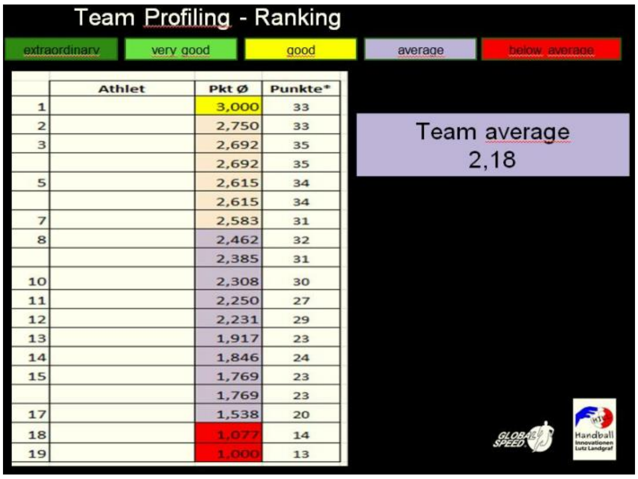
Information on	Points		Results *		Categories**					Test	Unit
	1	2	1	2	h	sg	g	m	u		
basic frequence	0		11,9		20	17,5	15	12	<12	Tapping	Coeffizient
basic reaction time	0		0,74		0,4	0,45	0,5	0,55	>0,55	Auge-Fuß	Time [s]
perception + start	2		0,902		0,7	0,8	0,9	1,0	>1,0	3m Zufall	Time [s]
basic speed	2		16,3		14	15	16	17	>17	Star Run fest	Time [s]
handball specific speed	0		11,4		4,5	4,8	5,1	5,4	>5,4	Abwehrlauf	Time [s]
perception time 1	0		21,3		15	17	19	21	>21	Speed Chase	Time [s]
perception time 2	2		5,3		1,3	3	4,5	6	>6	Star-Run (S-E)	Difference time S-E
decision time 1	0		0,5		0,1	0,2	0,3	0,4	>0,4	3m (S-E)	Difference time S-E
decision time 2	2		26,99		17	21	25	29	>29	Chase-Colour	Time [s]
speed with anticipation	4		15,99		14	16	18	20	>20	Chase-Next	Time [s]
complex cognitive speed 1	0		7,1		5,0	5,3	5,6	6,0	>6,0	Memory fest	Coeffizient
complex cognitive speed 2	0		11,3		6,0	6,5	7,0	7,5	>7,5	Memory free	Coeffizient
Change of direction Ø	0		0,398		0,2	0,25	0,3	0,35	>0,35	Different Tests	Contact time [s]
Change of direction left			0,30		0,2	0,25	0,3	0,35	>0,35	Different Tests	Contact time [s]
Change of direction right			0,417		0,2	0,25	0,3	0,35	>0,35	Different Tests	Contact time [s]

Sum points	12	
Ø points	0,92	

Focus for training (very good at anticipation):

- Basic handball specific speed plus change of direction
- Perception time
- Complex reactive agility
- Further observation on left-right misbalance of change of direction time

Figure 15



	Athlet	Pkt Ø	Punkte*
1		3,000	33
2		2,750	33
3		2,692	35
		2,692	35
5		2,615	34
		2,615	34
7		2,583	31
8		2,462	32
		2,385	31
10		2,308	30
11		2,250	27
12		2,231	29
13		1,917	23
14		1,846	24
15		1,769	23
		1,769	23
17		1,538	20
18		1,077	14
19		1,000	13

Figure 16

On examination of the qualities of the components and the average for reactive agility, it emerges that the team exhibits only an average level (Figure 16). According to the team ranking only one athlete reaches the level "good". The results illustrate strikingly how much potential for improvement of reactive agility exists, especially for the component of responsive speed.

On basis of the determined strengths and weaknesses, individual core areas for training can be defined for each athlete (cf. Fig. 14).

Figure 17

Special attention should be paid to the results for the change of direction (planned and random). Not only do the measured times bear a high potential for improvement, but a corrected course of movement (video analysis) already results in considerably faster times and significantly reduces the risk of injury. Observations showed that the majority of athletes didn't use an ideal course of movement and nor possessed a structural understanding of the execution of movement (cf. Fig.17).

Conclusions and prospects for the training

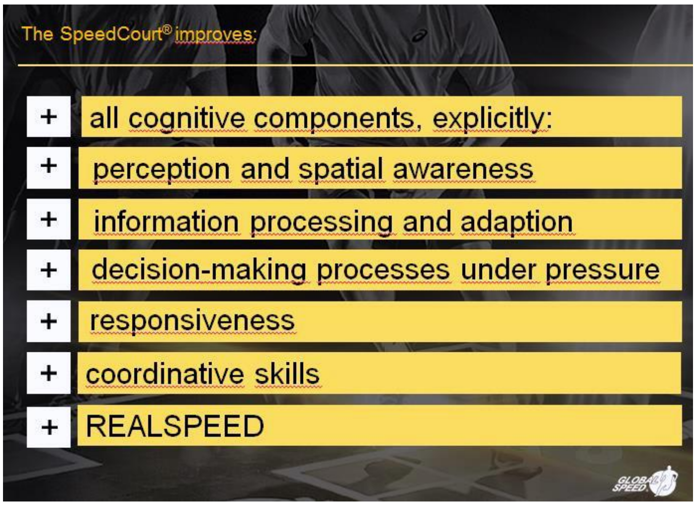


Figure 18

Long-term documentation of development of athletes who trained systematically and regularly on the SpeedCourt show significant improvements in all areas (cf. Fig.18).

On this basis we propose fundamental suggestions for a goal-oriented training planning and application of the SpeedCourt:

- All components of reactive agility can be trained, measured and improved
- According to our experiences, improvements in the performance on the SpeedCourt are directly transferable to a successful game performance.

- The SpeedCourt lends itself for training cognitive components, especially speed of perception and decision-making as well as responsive speed, on the one hand and for training change of direction on the other hand.
- That the SpeedCourt is necessary for analysis and training planning appears to be non-controversial.
- Our conclusions are supported by the recommendation after a trial run by the DHB youth team, "… that the training and diagnosis with the SpeedCourt will be implemented as a routine measure by the national teams".
- The hypothesis, that visual attentiveness and cognitive examination of reactive and movement tasks of athletes who are training on the SpeedCourt are significantly more developed than of those who haven't, should be further studied.
- Further benefit is added since other important components of performance (i.e. game specific fitness, psyche, rehabilitation, coping with high pressure situations) which are simulated on the SpeedCourt can be affected positively.

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CONCURRENT AEROBIC AND STRENGTH TRAINING IN ELITE TEAM HANDBALL

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Summary
In strength demanding sports like team handball, where the players periodically combine strength training with aerobic training, progress in muscle strength may be less than if solely strength training is performed. However, if the training frequency, intensity or duration of the aerobic training is reduced, the degree of negative interference between the two types of training decreases. If the aim is to improve the players aerobic performance without increasing the muscle mass, supplementary strength training for ongoing aerobic training in the form of training sessions with heavy loads and few repetitions have been shown to improve both the short- and long-term performance. Knowledge of the principles of concurrent training is important for the planning of optimal training regimens in elite team handball to increase performance and avoid overload injuries.

Keywords: Concurrent training, negative interference effect, explosive strength training, order of training, intercellular signal pathways

Introduction

The physical demands during team handball match-play are especially high for elite male and female players. In addition, elite players are required to perform constantly at a high level during the 9-10 months competitive match season, despite of the effects of their hard training and match schedules. During the season, it is often more common with two matches per week than one, and in various periods elite players are often training twice a day. Elite team handball is a complex sport, which imposes high demands on a variety of physical elements, e.g. aerobic power, maximal strength and anaerobic capacity (Michalsik et al., 2013, 2014, 2015a,b,c; Michalsik & Aagaard, 2015). To increase playing performance and reduce fatigue and the number of overload injuries, all these aspects need to be trained during the entire season. However, it is possible that the training adaptations are different from those obtained when the different types of training are conducted separately.

In many sports, it is common to combine aerobic training with strength training. The concomitant integration of these two types of training within a periodized training regime is being termed as concurrent training. Also for ordinary exercisers and older individuals, it is often recommended to combine aerobic training and strength training, as both the circulatory and musculoskeletal improvements not only reduce the risk of disease, but also enable people to perform daily activities without problems (Donnelly et al., 2009). In recent years, CrossFit training has become very popular. The training is described as a strength and conditioning program built around constantly varying functional movements performed with relatively high intensity. Thus, functional strength training is combined with aerobic high-intensity training (and anaerobic training) during the same training session. Here strength training and aerobic training are equally weighted.

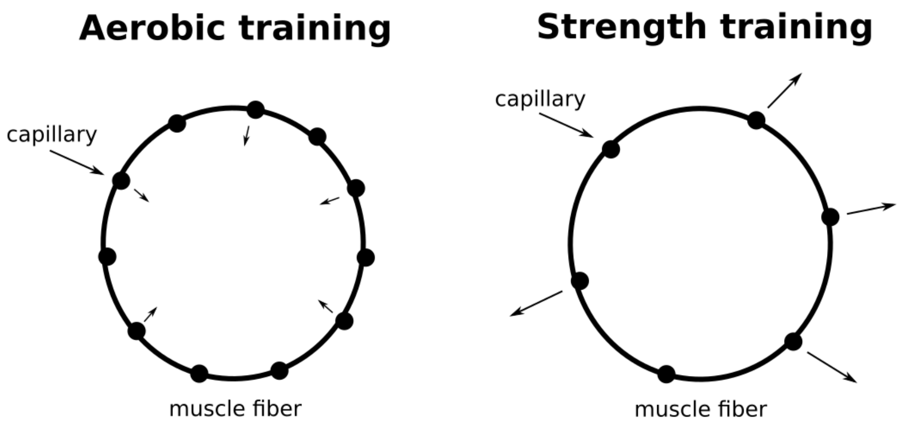
In team handball, it is crucial to improve these two physical elements in elite players in order to cope with the actual on-court playing demands. Strength training is being performed to enhance hypertrophy, maximal strength and power, which is needed during powerful playing actions like tackles, shots, fakes, blocks, jumps, side-cuttings, screenings and forceful changes of direction during the high number of physical confrontations with opponent players (Michalsik et al., 2013, 2014, 2015a,b,c; Michalsik & Aagaard, 2015). At the same time, aerobic training is executed to increase the level of aerobic performance (power and capacity) to keep up with the high intensity of match-play during the entire game of 2 x 30 minutes.

The amount of studies regarding concurrent aerobic and strength training in team handball are highly limited. Consequently, information about this form of training is based on results from studies of other sports, which have some similarities with team handball. Thus, these findings are used to complete the overall training principles for concurrent training in elite team handball, which are described in the present article.

Concurrent aerobic and strength training for improving aerobic performance

Aerobic training and strength training represent divergent training modes, both with regards to their training stimuli and the subsequent adaptations. Under normal circumstances, it is not possible to increase endurance and muscle strength at the same time, as the overall effects of the two types of training are opposed with very little overlap between them. Aerobic training improves the diffusion conditions by increasing the number of capillaries, and extensive aerobic training has even been shown to reduce the cross-sectional area of the muscle cells (atrophy), so the number of capillaries per muscle fiber area is further increased (see figure 1). This allows for better transport of oxygen, carbohydrate and fat from the bloodstream into the muscle cells as well as an increased removal of among other things heat and lactic acid from the exercising muscles. Conversely, strength training may enhance muscle mass by increasing the size of the individual muscle cell (hypertrophy). This means that there will be greater distance from the capillaries around the muscle cell and into the center of the muscle cell, where part of the mitochondria is located. Thus, the diffusion distance will be longer, and the possibility of exchange of nutrients and other substances reduced.

Figure 1. Illustration of the opposing effects of aerobic training and strength training. Aerobic training improves the diffusion conditions in the muscle cell, while strength training usually increases the size of the individual muscle cell (hypertrophy) and thus deteriorates the diffusion conditions.



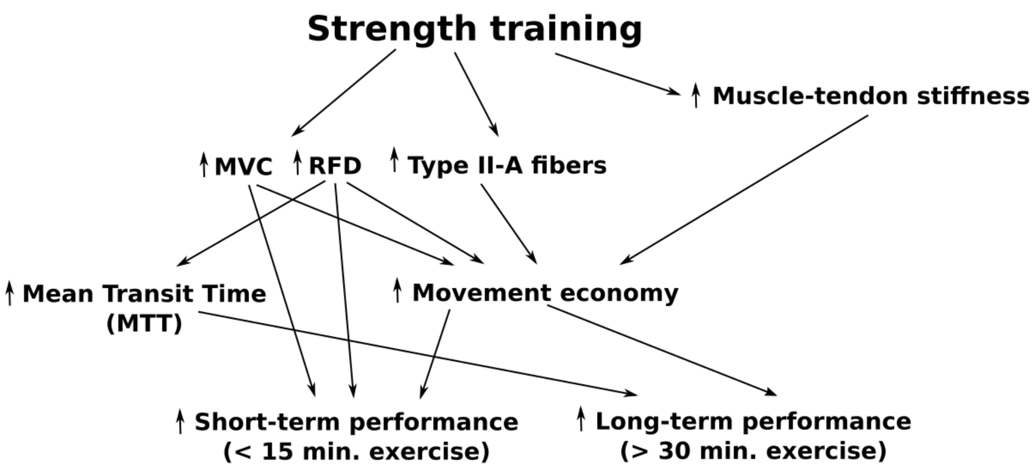
If the aim of the training is to improve the aerobic performance of some players without simultaneously increasing the muscle mass, e.g. in wing players who must be able continuously to run fast breaks and quick retreats, it is important that the players perform strength training that increases the muscle strength without increasing the muscle mass. This occurs by adjustments that enhance the efficiency of the nervous system. Furthermore, the diffusion conditions do not deteriorate. Increasing muscle strength without increasing muscle mass may improve the ability of the players to perform long-term exercise, e.g. to perform at maximum throughout an entire match (60 min) or in many matches during a long tournament. The strength training should be directed to the ability of the nervous system to activate the muscle fibers and be based on the principles of explosive muscle strength training (heavy loads and few repetitions performed at maximum intensity). However, it is important to emphasize that explosive strength training should only be performed after a long period of basic strength training (½-1 year), so that muscles, tendons and ligaments can slowly get used to the heavy training loads. Additionally, it is ensured that the fundamental lifting technique in the basic exercises is correct.

Studies with highly trained persons and elite endurance athletes have shown that they enhance both their short-term (<15 min exercise) and long-term (> 30 min exercise) performance after a period of supplementary strength training (Aagaard & Andersen, 2010; Aagaard et al., 2011; Aagaard

& Raastad, 2012; Damasceno et al., 2015). In order to achieve such improvements, a large total training volume is required over a long period of time (> 12 weeks, 2-3 times per week) and with high strengths loads corresponding to 2-6 RM (Repetition Maximum), which is the weight one can lift exactly 2 and 6 times (85-95% of maximum strength), respectively, in a given strength exercise. These training effects can be achieved without an increase in body weight and mass of the involved muscles. In the absence of measurable muscle hypertrophy, which usually occurs in strength training, the increased muscle strength is due to improvements in the nervous system.

The reasons for the observed improvements in aerobic performance (endurance capacity) include an increase in the number of type IIa fibers at the expense of type IIx fibers without changing the total muscle mass (and the capillarization). In addition, the training causes the maximum muscle strength and the ability for rapid force development (RFD) to increase (see Figure 2). By running, this means that when a particular force is produced at a given speed, it will represent a lower relative workload, which contributes to the enhanced aerobic performance. Furthermore, the increased RFD will mean that muscle power can be produced faster, and this allows for a prolonged relaxation phase at each step. This will lead to a reduced time where the blood vessels are compressed due to the contraction of the muscles, thus increasing the passage time (mean transit time) the blood has, as it passes through the muscles. Consequently, the time to exchange nutrients and other substances with the surrounding muscle tissue becomes longer. The result will be less muscle fatigue at a given load. The rise in RFD is primarily due to neural adaptation mechanisms such as increased maximum firing frequency from the motor units and reduced synaptic inhibition of the spinal motor neurons (located in the spinal cord) caused by the intensive and heavy load strength training.

Figure 2. Potential mechanisms which may contribute to increase the short-term and long-term performance of elite athletes by adding strength training to ongoing aerobic training. MVC, maximum muscle strength; RFD, rate of force development (Δforce/Δtime) - fast muscle strength; MTT, mean transit time - average passage time; Movement economy - measured via VO_2 at a submaximal load. The lines indicate a stimulatory effect.



The studies mentioned have also shown an improved movement economy (see Figure 2). This is probably due to the lesser relative workload and lesser compression of the blood supply to the exercising muscles. Furthermore, the studies have demonstrated marked muscle-tendon adaptations such as increased muscle-tendon stiffness and tendon hypertrophy. This increases the possibility of better utilization of elastic energy by concentric contractions during running, which will improve the running economy. The importance of the movement economy is emphasized by its close relationship with the endurance performance of trained persons with similar VO_2-max (aerobic power). An improvement in the movement economy will in itself lead to increased endurance performance capacity.

Concurrent aerobic and strength training for improving strength

Several studies have shown a decreased muscular adaptation when combining aerobic training and especially more traditional strength training with lower loads and more repetitions relative to RFD-training (Hickson, 1980; Lever M & Abernethy, 1999; Wilson et al., 2012; Rønnestad et al., 2012; Rønnestad & Mujiks, 2014; Fyfe et al., 2014). This phenomenon is often described as the interference effect or concurrent training effect. The interference effect typically manifests as a compromised strength training adaptation compared to enterprise strength training alone. Especially in aerobic high-intensity training, the effect of the subsequent strength training session and the development in muscle strength, hypertrophy and power are not optimal.

Kraemer et al. (1995) e.g. found that aerobic training in terms of running consisting of high-intensity exercise and strength training performed 4 days a week for 8 weeks resulted in lower force development and less muscle fiber hypertrophy compared to strength training performed alone. The strength training produced an increase in muscle mass of 28%, while concurrent strength and aerobic training only resulted in a muscle growth of 16%. This indicates that at concurrent aerobic and strength training, the aerobic training reduces not only the development in strength, but also the muscle growth. This is in accordance with the results of the classic study by Hickson (1980), who was the first to describe the interference effect, which showed that aerobic high-intensity training reduces muscle strength development (see Figure 3).

The less progress in muscle strength in the above-mentioned and other studies may be due to the fact that several of these studies have had a high frequency of strength training (up to 6 days a week) combined with high-intensity or large-volume of aerobic training. This may have reduced the recovery time between training sessions too much. In addition, the subjects have often not been highly trained or elite athletes. If aerobic training is to be combined with strength training, it is therefore important to emphasize that aerobic training or strength training cannot just be added to the normal training program, but must to some extent replace other training, so that the total volume of training does not get too high.

Figure 3. The classic study of Hickson (1980), which shows the effect on strength development of combining strength training and aerobic training. The figure shows the increase in 1 RM in the squat exercise for subjects who performed a 10-week training program with aerobic training (AT, 5 times a week), strength training (ST, 5 times a week) or both types of training (CT) in the same extent. Note that both the ST and CT groups increased their strength in the same way until the 7th week after which the ST group continued to increase their strength. The CT group, on the other hand, experienced a decrease in strength, which indicates overreaching, or that aerobic high-intensity training prevents long-term development in muscle strength.

In elite team handball, different types of training are often performed during the same training session, the same day or the same training period, respectively. This applies especially to aerobic training and strength training. Concurrent aerobic and strength training can be planned in several ways, depending on the players´ overall objective of the training. It can be performed concurrently during the same training session or on one day by splitting the training into two, e.g. with aerobic training in the morning and strength training in the evening. Furthermore, the various types of training can be placed on different days, for example with aerobic training on Mondays, strength training on Tuesdays, etc. By training periodization, certain periods can contain mostly aerobic training, while other periods may focus mostly on strength training.

If the two types of training are part of the same training session, they can reduce each other's effect. Several studies have shown a decreasing strength development in the subsequent strength training session after intense aerobic training (see Wilson et al., 2012). If the session starts with aerobic high-intensity training, the effect of strength training will not be not optimal. Studies have also shown a diminished growth hormone response after 1 hour of continuous cycling with moderate intensity, suggesting that strength training should be performed at least several hours after aerobic training if a player wants a favourable hormone response during and after exercise, or it should be placed before the aerobic training. However, if the aerobic exercise and the subsequent strength training are both performed at moderate intensity, the training effect may well be optimal even if they are part of the same training session.

The order in which the aerobic training and strength training is conducted, when they are included in the same training session, is important. It is partly due to the fatigue that has occurred after the first type of training. This may interfere with the ability to perform in the subsequent training, whereby reducing the quality of the final training and thus of the total training session (Kang & Ratamess, 2014. At present, there seems to be no consensus on which training order is most effective. Thus, recommendations regarding the optimal training order depend on what type of training that is most important for the individual athlete. Team handball players who need improvements in endurance and aerobic power should prioritize aerobic training and start with this if the two types of training are included in the same training session. This is especially true in the case of aerobic high-intensity training.

Studies have shown that the muscle strength in the legs after intense aerobic cycling training was significantly reduced until 6-8 hours after the training, whereas the strength of exercises with the upper body musculature was not reduced (Leveritt & Abernethy, 1999; Sporer & Wenger, 2003). This indicates that only the muscle groups activated by aerobic training are affected by subsequent strength training. If the strength training is placed at the end of the training session, it can be performed at maximum if executed with other muscle groups than those used for aerobic training. However, strength training should primarily involve the muscle groups used during aerobic training (i.e. those used in the competitive situation). The listed order is especially relevant for endurance athletes, as the requirements for muscle strength and power are not so significant for these athletes. If the primary focus is the increase of muscle strength as in most elite team handball players, strength training should be performed first, favouring the improvement of muscle strength and power in the individual training session (Kang & Ratamess, 2014).

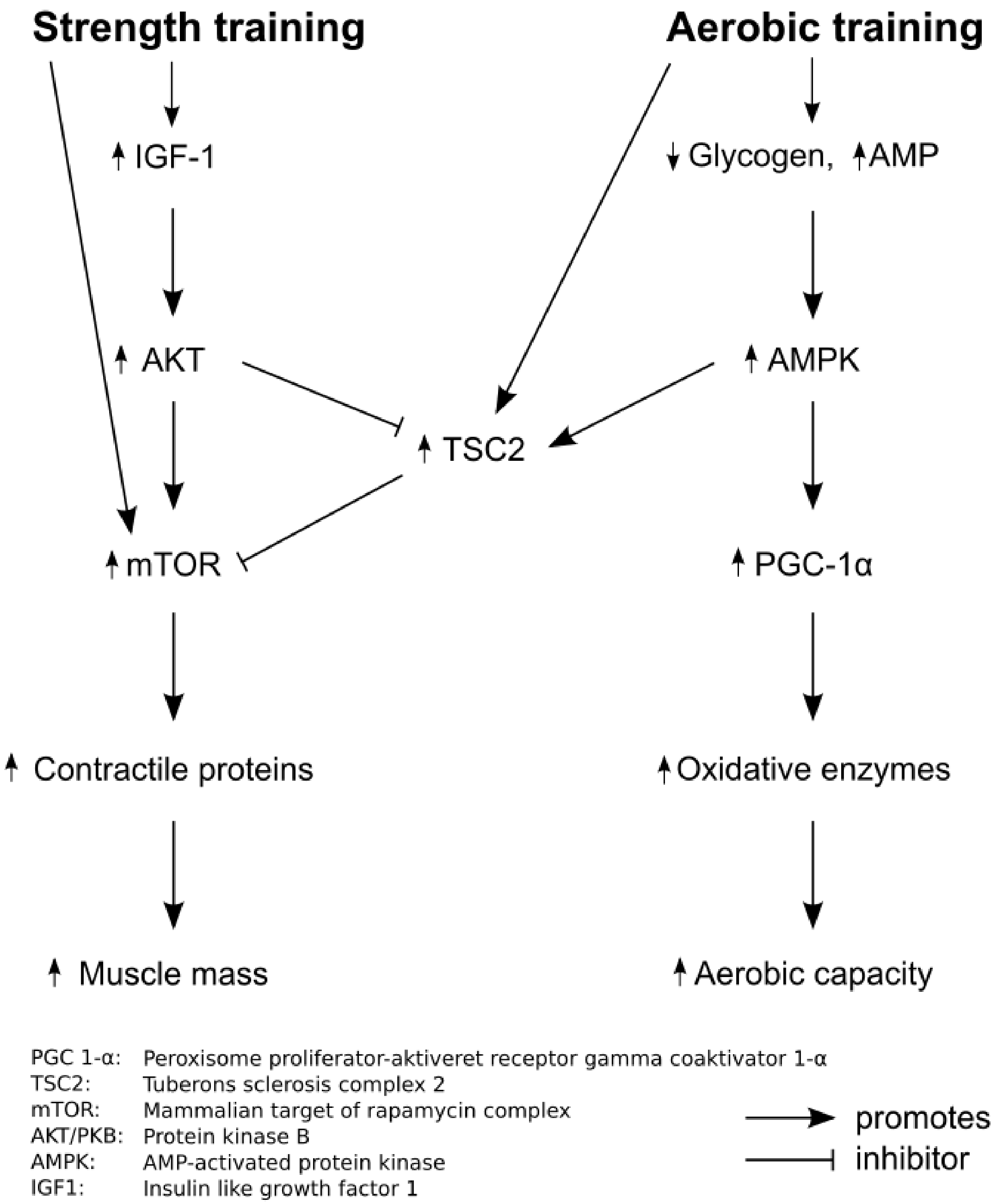
If training on one day is divided into two training sessions, e.g. aerobic training in the morning and strength training in the evening, or at separate training sessions on different days or by favouring one type of training in certain periods, the problem with the fatigue effect of prior training is avoided. This allows the players to train with the same muscle groups and high intensity for both types of training if the players are well-trained (fast to recover). However, this may be difficult to plan for elite athletes in endurance sports that often practice aerobic training twice a day.

There is a great need for muscle growth and large muscle strength in elite team handball. If elite players combine their strength training with aerobic training in a period, the increase strength will be reduced compared to if they only trained strength training (Leveritt M & Abernethy, 1999; Rønnestad et al., 2012; Rønnestad & Mujika, 2014; Fyfe et al., 2014). However, it is important to note that when the training frequency, intensity or duration of the individual aerobic training session is reduced, the degree of negative interference between the two types of exercise decreases (Wilson et al., 2012). Cycling seems to be somewhat less disruptive to strength adaptations compared to running. Studies have e.g. shown that cycling three days a week with 50 minutes duration per training session at an intensity corresponding to 70% of VO_2-max for 10 weeks did not impair either muscle strength or muscle growth by simultaneous strength training (McCarthy et al., 1995, 2002). However, elite team handball players should primarily train by running, not by cycling.

Overall, the available data shows that strength development and aerobic exercise ability can be increased simultaneously to a certain point. If the training frequency for the aerobic training increases to 4 times a week or more, or if the training intensity increases to more than 80% of VO_2-max, aerobic training may reduce the increase in muscle mass and muscle strength that occurs in strength training (Wilson et al., 2012). To optimize strength development and muscle growth, it is advisable to reduce the amount/intensity of aerobic training and or increase the volume of strength training.

The fact that concurrent aerobic and strength training result in less training effects compared to if these types of training are performed separately, can be explained at the molecular level (Nader, 2006; De Souza et al., 2013; Baar, 2014; Fyfe et al., 2014; Coffey & Hawley, 2017). It is now clear that different types of training induce opposing intercellular signal mechanisms that may negatively interfere with skeletal muscle adaptation to the particular form of training. Specific signal mechanisms in the cell involving signal pathways and special protein substances such as AKT, mTOR and AMPK (see Figure 4) are activated by strength training and aerobic training, respectively. AKT and mTOR can both activate the production of proteins and reduce protein degradation, which in turn leads to muscle hypertrophy, whereas AMPK´s intercellular signal pathways can increase the number of mitochondria, glucose transport proteins and other factors that lead to improved endurance. These intercellular signal pathways can also inhibit and block each other. Consequently, the activation of AMPK by aerobic training may limit the synthesis of contractile elements by inhibiting the activation of mTOR and its signalling pathways (see Figure 4). Thus, reduced muscle hypertrophy occurs compared to when strength training is performed alone.

Figure 4. Simplified overview showing the different intercellular signal pathways of the muscle cells, which are activated by strength training and aerobic training, respectively. Strength training initiates an increase in the activity of signal substances including AKT and mTOR (protein kinases) that stimulate protein formation and muscle growth. Aerobic training is associated with signal pathways that are involved in among other things regeneration of mitochondria, which contributes to increasing the capacity of aerobic exercise. This comprises e.g. AMPK-signalling. Activation of AMPK via aerobic training may inhibit mTOR-signalling and thus suppress the strength training induced protein formation.



Based on the existing molecular knowledge, some simple nutrition and training strategies should be followed to optimize the adaptations for concurrent aerobic and strength training performed on the same day in sports like team handball, where muscle strength is important. After aerobic high-intensity training, there should be a recovery period of at least three hours, as the AMPK-activity first returns to the rest level three hours after the end of the training. In return, the activity of mTOR may be increased up to 18 hours after strength training. Thus, it is not advisable to perform aerobic training after intensive strength training on the same day. Moreover, it is important with adequate food intake between the aerobic high-intensity training and the strength training, since e.g. AMPK, which may inhibit protein synthesis, may be activated by a low glycogen content in the muscles. If, the players, on the other hand, perform aerobic moderate-intensity training with a duration that does not empties the glycogen stores, the players can perform strength training immediately after aerobic training. It actually causes a greater stimulus for aerobic training adaptations than if the aerobic training is performed alone, and the intensity during the aerobic moderate-intensity training is so suitably low that it will not affect the molecular pathways leading to muscle strength improvements.

Key points of concurrent aerobic and strength training in elite team handball

The science of concurrent aerobic and strength training is relatively new. In addition, the amount of studies in team handball are highly limited. Thus, at present the overall training principles for concurrent aerobic and strength training in elite team handball is primary based on results from studies of other sports. Consequently, it is very important to gain more knowledge of this type of training in elite team handball. Future studies about concurrent training in team handball should be conducted to enable the trainers to provide evidence-based recommendations for the future planning and implementation of optimal physical training in elite team handball. Currently, it is crucial that the concurrent aerobic and strength training is planned very carefully, since it is obvious complicated, and e.g. not optimal just to include classic CrossFit-training in the physical training for elite team handball players for the development of among other things muscle strength. At present, the key points for concurrent aerobic and strength training in elite team handball are as follows:

For improving aerobic performance in elite team handball:

- Additional strength training can improve aerobic performance by increasing the maximum muscle strength, RFD and improving the movement economy.
- If strength training is not going to increase muscle mass and overall body weight, it should be aimed at improving the neural factors.
- This type of strength training is carried out with heavy loads, few repetitions and explosive execution (maximum acceleration of the weight) as well as with long pauses between each set, exercise and training session (explosive strength training) and with a large total training volume.
- Explosive strength training should only be implemented after a long period of basic strength training that is performed to get the body accustomed to heavy training loads.

For improving muscle strength in elite team handball:

- At concurrent strength and aerobic training, the development in muscle size and strength may be less than if only strength training was performed.
- When the training frequency, intensity or duration of the individual aerobic training session is lowered, the degree of negative impact of the aerobic training decreases.
- In order to optimize strength development and muscle growth, it is therefore advisable to reduce the amount/intensity of the aerobic training and/or increase the volume of strength training.
- Furthermore, cycling seems to be somewhat less disturbing for strength adaptations compared to running.
- Aerobic training and strength training should as far as possible not be included in the same training session for elite team handball players, and there should optimally be at least 6-8 hours of recovery after intense aerobic training before strength training is performed.
- It is important to consume carbohydrates after an aerobic high-intensity or long-lasting moderate-intensity training session, if strength training is to be performed later in the day.

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PHYSICAL PREPARATION OF A WORLD CLASS FEMALE HANDBALL TEAM FOR THE OLYMPIC GAMES IN RIO 2016 ON HOME GROUND

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Summary
The Brazilian Female National Handball Team´s preparations for the Olympic Games in Rio 2016 on home ground were very comprehensive. Due to the higher physical requirements to an Olympic tournament, the physical training needed be extra carefully planned and implemented to improve not only the on-court performance during match-play, but also to increase the ability to recover, reduce exercise-induced fatigue and hereby the incidence of overload injuries, and thus to perform optimally throughout the entire Olympic tournament period. This article aims only to give an overall description of the physical preparations, which were based on a combination of profound knowledge of the players, practical experience and scientific training principles. However, during the six months of preparation, the planning of the physical training was sometimes complicated, since the players most of the time in the first three months were training and playing for their respective clubs.

Keywords: Brazilian Female National Handball Team, Olympic Games, physical preparation, physical training principles, planning of the training

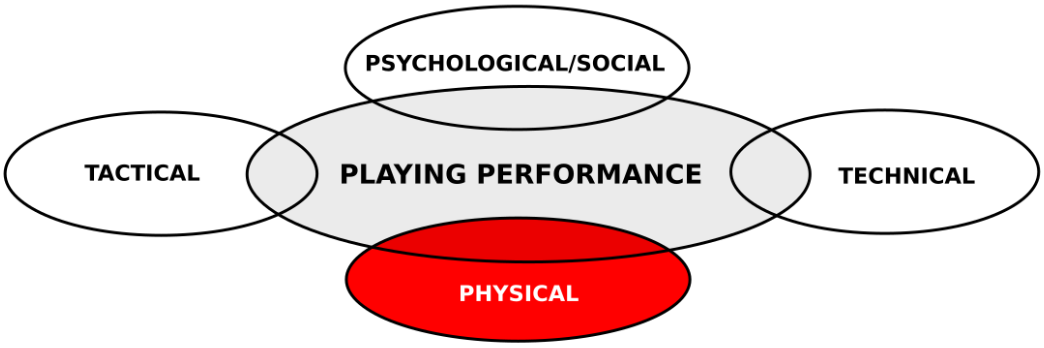
Introduction

Team handball is a professional and Olympic sport that has shown increasing popularity over the last decades. Since the handball game has its origins in Europe, naturally the game is also most popular there. However, the game has spread, especially in the last 30 years, to other parts of the world such as North Africa to include nations like Egypt, Tunisia and Algeria, as well as South and Central America with for example Brazil, Argentina and Cuba, and Asia with nations like China, Japan and Korea. The strongest professional leagues in the world are still situated in Europe, and team handball is the most popular indoor sport in many European countries. Here, full-time professional leagues can be found in more than 15 countries (e.g. Denmark, Germany, France, Spain, Croatia, Serbia and Hungary), with 200-250 players employed per league for both men and women.

Nevertheless, over the last decades countries from other continents of the world like Brazil have reach world class level in team handball. The Brazilian Female National Handball Team began their entry into the international top-elite with a fifth place at the World Championships in Brazil in 2011, continued with a sixth place at Olympic Games in London in 2012, and surprised everybody by winning the World Championships in Serbia in 2013. Thus, there were considerable expectations and the Brazilian team´s preparations for the Olympic Games in Rio 2016 on home ground, where the author of this article participated as their physical trainer, were very comprehensive. This article aims only to give an overall description of the physical preparations (see figure 1).

When participating in international team handball tournaments like the Olympic Games, national teams must play multiple matches over a brief period (in Rio - 8 matches in two weeks). Additionally, the number of players on each team is reduced from 16 to 14 players. Therefore, the fewer players not only have to cope with the increased physical demands, the high match frequency requires that they also must be able to recover faster due to less time between the matches. Consequently, the physical preparation to an Olympic tournament must be extra carefully planned and implemented because of the higher physical requirements to improve not only the on-court performance during match-play, but also to increase the ability to recover, reduce exercise-induced fatigue and hereby the incidence of overload injuries, and thus to perform optimally throughout the entire Olympic tournament period.

Figure 1. Playing performance in team handball is determined by the players´ technical, tactical, psychological/ social and physical characteristics. All the elements are of high importance in team handball and also closely interlinked, making team handball a particularly complex type of sport. For example, a high level of physical conditioning is required, if elite team handball players should be able to exploit their technical and tactical qualities during an entire game. Likewise, if a player´s tactical skills are deficient, the technical quality of the player may not be fully utilized.



Elite team handball is characterized by sixty minutes of fast, intense and dynamic activities such as repeated accelerations/decelerations, jumps, shots, rapid changes of direction and with a high number of physical confrontations with opponent players (Michalsik et al., 2013, 2014, 2015a,b,c; Michalsik & Aagaard, 2015). It is determined by the individual performance of each player as well as the tactical components and interaction of the players on the team. Elite team handball is a physically demanding contact team sport performed intermittently by players, who must be able to execute many different movements such as running, side-cuttings and different technical playing actions like tackles and screenings. Consequently, elite team handball is a complex sport, which imposes high demands on a variety of physical elements, e.g. aerobic power, maximal strength, explosiveness and anaerobic capacity (Michalsik et al., 2013, 2014, 2015a,b,c; Michalsik & Aagaard, 2015). To increase playing performance and reduce fatigue and the number of overload injuries, all these aspects needed to be trained by the Brazilian players during the entire Olympic preparation period.

There is a large diversity of programs used for physical training and other preparations for elite team handball players. Therefore, general physical training principles must be related to the specific team, and to the players´ position on the court, their individual physical capacity and need for recover, and to their gender (Michalsik et al., 2013, 2014, 2015a,b; Michalsik & Aagaard, 2015). Thus, the physical training was planned based on a combination of profound knowledge of the players, practical experience and scientific training principles. Most of the present players also participated in the Olympic Games 2012 in London and in the World Championships in 2013 and 2015. There is no precise optimal training plan, who can be used of all teams. Instead the general training principles must be adapted to the particular team and the specific situation. However, this present preparation plan might serve as a possible overall physical training plan for future tournaments.

The preparation period for the Olympic Games in Rio

There was a huge focus on a good result for the Brazilian Female Handball Team on home ground in Rio. Many resources were used for training camps and tournaments in Europe and in Brazil. Thus, the team was gathered for training and match-play significantly more compared to the preparation for other tournaments (see Table 1). Around 80% of the players were playing for clubs in Europe, so most of the preparation in the early phase took place in Europe, particularly in Vienna. The overall training and match schedule was very intense, especially for the players who were playing in European top-clubs. Some players e.g. participated both in their national tournament and also in the Champions League, where a few of them played the final on May 25 - the day before the Brazilian National Team started their own long preparation phase with a training camp in Denmark (see figure 2). Naturally, the load of these players due to their hard programs with the club were considered when planning their training in this phase of the preparation.

Table 1. The overall 2016 activity plan for the Brazilian Female National Handball Team for the preparation for the Olympic Games in Rio. The start of the Olympic Female Team Handball tournament for the Brazilian Female National Team was August 6. Grey represents days with training and match-play within the players´ own club, light blue represents days with training/match-play or tournaments with the Brazilian Female National Team, and green represents days with individual physical training during "summer breaks".

	JANUARY	FEBRUARY	MARTS	APRIL	MAY	JUNE	JULY	AUGUST
1	Club					Vienna	Rio	Rio
2						Vienna	Rio	Rio
3						Vienna	Rio	Rio - Olympic Village
4						Vienna	Individual	OG Rio
5			Club			Vienna		OG Rio
6			Vienna			Vienna		OG Rio
7			Vienna			Slovakia		OG Rio
8			Vienna			Vienna		OG Rio
9			Vienna			Vienna		OG Rio
10			Vienna			Vienna		OG Rio
11			Vienna			Individual		OG Rio
12			Vienna					OG Rio
13			Vienna					OG Rio
14			Vienna					OG Rio
15			Vienna					OG Rio
16			Norway					OG Rio
17			Norway					OG Rio
18			Norway					OG Rio
19			Norway					OG Rio
20			Norway					OG Rio
21		Club	Club				Individual	OG Rio
22		Brazil				Individual	Rio	
23		Brazil				Rio	Rio	
24		Brazil				Rio	Rio	
25		Brazil			Club	Rio	Rio	
26		Brazil			Denmark	Rio	Rio	
27		Brazil			Denmark	Rio	Rio	
28		Brazil			Denmark	Rio	Rio	
29		Brazil			Denmark	Rio	Rio	
30		Club			Denmark	Rio	Rio	
31					Denmark	Rio	Rio	

During the six months of preparation, the planning of the training was sometimes complicated, because the players most of the time in the first three months were training and playing for their respective clubs. This will always be a problem for any national handball team, since there often are different priorities and training methods in the players´ clubs compared to the national teams. In this case, very surprisingly many of the clubs with Brazilian players did not have full-time physical trainers or physical trainers with a team handball background or knowledge. Consequently, the physical training was in many cases not optimal. In addition, almost all of the clubs wanted to peak the physical performance of the players to their national play-offs or to the Champions League in April/May, and not in August as the Brazilian Female National Team. However, after a good dialog it was possible for some of the players to follow most of the Brazilian National Team´s physical training schedule and training principles. Moreover, four of the players in the Brazilian squad played for clubs in Denmark, near Copenhagen. Therefore, physical training was performed in Copenhagen with these players on a regular basis in this period.

The physical training

The overall planning of the training

Overall, the physical training consisted of aerobic, anaerobic and strength training, respectively. In addition, prevention training exercises were always included in the warm-up. Anaerobic training was only in focus in the end of the preparation period and was always performed on-court with a ball. Furthermore, individual on-court physical functional training was also included in the training, e.g. how the players could use their strength better in one-to-one situations, increase their speed in the run-up to shoot faster or enhance their jumping ability in realistic match situations. The players performed specific physical training in relation to their playing position, individual capacity and training status and need for restitution, meaning that all players did not perform physical training with the same content and amount. This was practical possible, because we had an intensive knowledge of almost every player's training background since the previous Olympic Games in London, and of their present training status and physical needs when playing on the court. Furthermore, we had practical experience in working with these players and knowledge about the evidence-based physical training principles in the different training categories.

To optimise the performance, the physical training was periodized, but especially in the first half of the preparation period, it was almost impossible to control the exact intensity, frequency and volume of the physical training when the players trained mostly at their clubs. Consequently, on this background it was decided to use an overall linear periodisation model for the physical training (Fleck & Kraemer, 2014; Haff, 2016). This refers to a relative linear increase in the training intensity and a relative linear decrease in the training volume within a training macrocycle, as the players only worked towards one peak of their performance - namely at the Olympic Games. The preparation period ended with a taper the last couple of weeks to peak the physical performance even more to the start of the Olympic team handball tournament. During the taper, the physical training volume was reduced significantly, whereas the training intensity was maintained or even increased (Pyne et al., 2009; Rønnestad et al., 2017). This included a more intense focus on RFD-strength training and on-court anaerobic functional training. During the whole preparation period, there were also focus on training of players with limited or no playing time in the matches.

In team handball, it is crucial to improve the aerobic and strength performance in elite players in order to cope with the actual on-court playing demands. However, if the players periodically combine strength training with aerobic training, progress in muscle strength may be less than if solely strength training is performed (Wilson et al., 2012; Rønnestad et al., 2012; Fyfe et al., 2014; Michalsik, 2017). Consequently, aerobic training and strength training were never included in the same training session. During the two periods in June and July, the players did not train with their club or the national team, but instead performed individual physical training most of the time twice in a day. In the latter case, there was at least 8 hours of recovery after intense aerobic training before strength training was performed. During these two short "summer breaks" all players had an individual physical training program, which was designed according to their needs and primary physical area of focus. In general, the physical training consisted of strength training (incl. functional exercises) and aerobic training. However, in the second period some anaerobic training elements were included.

During the preparation period to the Olympic Games in London, the Brazilian Female National Team spent a lot of time testing the players. Consequently, nearly all players were familiar with all the various tests and test procedures normally used to test players in elite team handball. However, testing takes a lot of time from the normal training schedule, not only because it takes time to complete the actual testing, but also because of standardisation procedures, e.g. all or almost all training must be avoided the day before the testing. Consequently, it was decided to use only a minimum of testing in this preparation period. The physical level of the individual players was followed very closely during the different training camps and in addition, in the first three months information was acquired from test results from the testing performed in the players´ clubs. Thus, the individual training load, e.g. during the strength training, could be adjusted according to the development in the physical performance of the players. The principle of training progression was therefore used (Fleck & Kraemer, 2014). A treadmill VO_2-max test was performed, as the Brazilian Olympic Committee wanted to use this test to obtain information of the general physical and medical health of all Brazilian Olympic athletes. Moreover, the Yo-Yo intermittent recovery test (level 1) was used in several cases in the last half of the preparation period to test the players´ ability to perform high-intensity intermittent exercise and to recover after repeated high-intensity exercise. Finally, the body composition of the players was tested throughout the entire preparation period on a regular basis.

Aerobic training

Aerobic training can be divided into three overlapping areas: Low-intensity training, moderate-intensity training, and high-intensity training, as described by Michalsik (2015). The training intensity was assessed by using measurements of the heart rate and was regulated according to the player´s own maximum heart rate. Table 2 illustrates the principles behind the various categories of aerobic training. When aerobic training is performed with a ball, the definition of the three categories takes into consideration that the heart rate will alternate continuously during training, since the intensity can depend on the players´ direct involvement in the game and therefore can be difficult to control precisely. Thus, an acceptable primary area (range) is designated.

Table 2. The heart rate (HR) during aerobic training. # An example with a maximum heart rate of 200 beats/minute is shown.

	Heart rate (% of HR_{max})		Heart rate # (beats/minute)	
	Mean	Range	Mean	Range
Low-intensity training	65%	50-80%	130	100-160
Moderate-intensity training	80%	70-90%	160	140-180
High-intensity training	90%	80-100%	180	160-200

Since the physical training of a handball team only constitute a part of the total training volume and time (see Figure 1), the aerobic training for the Brazilian female players focused mainly on aerobic high-intensity training. This training was performed on a regular basis from the start of the preparation period, particularly for selected players. Training was carried out both on-court with the ball as well as by outdoor formal running or by treadmill running in the gym. During the two periods with individual training in the summer period ("summer holidays"), the players performed formal aerobic high-intensity training 3-5 times/week. For variation, the players could choose between various kinds of aerobic high-intensity running training, all of which had the same aerobic training effect:

A) Long intervals: 1) Warm-up: 10 min´s jogging & stretching. 2) 5-6 x 3 min´s running - pause 3 min´s jogging in between. 3) Recovery: 10 min´s jogging & stretching. B) Short intervals: 1) Warm-up: 10 min´s jogging & stretching. 2) 10-12 x 1½ min´s running - pause 45 sec.´s jogging in between. 3) Recovery: 10 min´s jogging & stretching. C) Very short intervals - 10-20-30 training: 1) Warm-up: 10 min´s jogging & stretching. 2) 2-3 series x 5 min´s of 10-20-30 training - pause 3-5 min´s jogging between series. 3) Recovery: 10 min´s jogging & stretching. D) Pyramid training -

well suitable for treadmill running: 1) Warm-up: 10 min´s jogging & stretching. 2) 2-3 series of 3 min, 2 min, 1 min with increasing speed - pause 3-5 min´s jogging between series. 3) Recovery: 10 min´s jogging & stretching. E) Continuously running: 1) Warm-up: 10 min´s jogging. 2) 15-20 min´s running at high aerobic speed. 3) Recovery: 5-10 min´s jogging & stretching.
All the players were familiar with the various kinds of running and aware of their individual optimal training intensity, as all these methods had been tested by formal running training at training camps with the national team. The last month of the preparation, aerobic high-intensity training was only performed 1-2 times each two week, since anaerobic training now was given greater priority as the start of the Olympic Games approached.

Anaerobic training
Anaerobic training can be divided into two main training areas speed training and speed endurance training, as described by Michalsik (2015). The latter can be further divided into production training and maintenance training. The three training areas are overlapping (see Table 3).

Table 3. The principles for formal anaerobic training. The exercise intensity is expressed in percentage of the individual maximal exercise intensity. When the training is conducted with the ball, the ratio between the duration of exercise and rest/active recovery can often be reduced compared to the values presented, since the players are not constantly working at high intensities due to natural variations in the game.

Training area	Duration		Exercise intensity	No. of repetitions
	Exercise (s)	Rest		
Speed training	2-10	> 10 times exercise duration	100%	2-15
Production training	10-40	> 10 times exercise duration	60-100%	2-15
Maintenance training	10-120	3-5 times exercise duration	30-100%	2-15

Since anaerobic training is performed with a much higher intensity than in aerobic training, all the anaerobic training was performed according to the interval principle. All anaerobic training with the Brazilian Female National Team was performed on-court in game-like simulations (i.e. with ball handling involved), since such training has several advantages (Michalsik, 2015). 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. Finally, training with a ball will be more motivating for most players. For example, part of the desired speed training effect was to improve the player's ability to anticipate, evaluate and decide in different on-court playing situations, e.g. the start signal could be the completion of a shot or the bounce of a ball. In team handball, speed is not just a matter of physical capacity, it also involves quick decisions that must then be transferred into fast actions. However, there were a couple of circumstances where the speed training was performed without the ball (formal training), because some of the players tended not reach the right exercise intensity with the ball due to technical and tactical limitations.
The speed training was always performed in the beginning of the training sessions when the players were fresh and after a proper warm-up. In contrast, the speed endurance training was performed at the end of the training sessions, because the training was so demanding that players was physically

affected for a long time afterwards. The latter training form was first included in the training 4-5 weeks prior to the start of the Olympic Games and was performed 3-5 times per week.

Strength training

There was a strong focus on various aspects of strength training in the light of the high demand in female top-elite team handball for rapid force capacity (i.e., high rate of force development, RFD) during fast and hard shots, the need for rapid body accelerations and changes of direction, and the high number of physically demanding confrontations (i.e., tackles, screenings, claspings, and blockings). At the start of the preparation period, an individual need analysis was performed in collaboration with the head coach in order to be able to fulfil the overall team playing strategy for the up-coming Olympic Games. This information was used to individualize the strength training programs. Consequently, some players needed to gain muscle mass, which was developed and trained as *hypertrophy training*. Increasing muscle mass in elite team handball players may take a long time. Thus, the selected players started this type of training immediately. However, this was in some cases in conflict with the present aim at the clubs, since there were in middle of the competitive season.

This training comprised a large total volume of strength training with many exercises, and many sets and little rest between sets and exercises (see Table 4). This seems to induce fatigue, which may be very important for muscle growth. A few players had some difficultly in gaining muscle mass. These players supplemented their training with Kaatsu-training (blood flow restriction training, see e.g. Vanwye et al., 2017). Other players just needed to be stronger and therefore performed *maximal strength training*. During the "summer breaks", the players were performing strength training 4-5 times per week. Every player had her own individual strength training program, which was changed each 4-6 week. Some basic exercises were included in every program, but new exercises were continually incorporated. In accordance with the linear periodization model, all players - at the end of the preparation period - focused on becoming more explosive and peaking their performance by conducting *RFD-training*, i.e. performing few repetitions with heavy loads, and long rest between the relatively few sets and exercises. This training was periodized during the last period and also during the Olympic Games to promote peaks in strength performance at the most important matches.

Table 4. Example of a starting strength training program to the development of hypertrophy. The training was performed with little rest between sets and exercises.

Combination exercise only with barbell	3 x 10
Squat to bench (to 90°)	8-6-6-4-4
Bench press	8-6-6-4-4
- immediately followed by:	
Spiderman push-ups - alternately left and right with short pauses between series	3 x (2x6) L/R
Power clean with short pauses between the last two series	6-6-6-10-10
Side dumbbell lateral raise with assistance from the legs	
with short pauses between the last two series	6-8-10-10
Abdominal raise with weight in straight arms with short pauses between series	4 x 8
Standing dumbbell biceps curl and overhead shoulder press with rotation	6-6-10-10
Incline lat pulldown with short pauses between the last two series	6-6-10-10
- immediately followed by: Chin-ups	3 x 8
Field players: One leg jumping on low box - alternately left and right	3 x (2x10) L/R
Goalkeepers: Two leg jumping on high boxes - 5 times back and forth	3 x 5

The players must preserve or even improve their acceleration capacity, ability to perform rapid side-cutting manoeuvres, maximum jump height and mobility as well as aerobic power despite at the same time becoming heavier (more muscular) to push away in a breakthrough and to more effectively tackle opponent players in defence. Consequently, specific *functional strength training*

regimens to improve these capacities was performed, which included on-court sprinting, maximal vertical jumping drills, and tackles and blocks performed as game simulations.
In conclusion, the described physical training led to marked improvements in body composition and physical performance both for individual players and for the team. Thus, the Brazilian female team handball players became ready for the opening match at the Olympic Games in Rio at August 6 against the probably most physical well-trained team in the world, Norway. The match was won by 31-28.

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

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Summary

This study aimed at examining the physiological demands and musculoskeletal and cardiovascular fitness effects of a short-term recreational team handball-based exercise programme on sedentary postmenopausal women with no previous experience in the sport (n=35). After 16 weeks, the recreational team handball group showed positive alterations on cardiovascular fitness, lumbar spine and hip bone mineral density and body composition.

Keywords: recreational team handball, health, physical fitness, physiological demands, postmenopausal women.

Introduction

Low levels of physical fitness are one of the most important risk factors for cardiovascular diseases (Warburton, Nicol, & Bredin, 2006). This can be counteracted by physical activity (PA) and exercise programmes, since they have shown to act as primary prevention against several chronic conditions (Booth, Roberts, & Laye, 2012). Nevertheless, the population worldwide is not meeting the PA recommendations (Hallal et al., 2012). Consequently, it is urgent from a public health perspective, to identify other exercise modes than those traditionally offered to the population, such as running or strength training, that can meet the PA guidelines, while keeping the participants motivated and assuring long-term adherence.

Recreational football training programmes have led the way in describing the relation between team sports and health. Short-term interventions using small-sided games have shown positive marked improvements in cardiovascular, metabolic and musculoskeletal health markers such as maximal oxygen uptake (VO_2max), heart function, blood pressure, lipid profile, muscle mass, bone mineral density (BMD), bone mass, muscle strength and postural balance, resulting in a lowered risk of falls and fractures of several populations (Bangsbo, Hansen, Dvorak, & Krustrup, 2015). However, the health and fitness effects of other team sports have not been extensively studied so far.

Recently, Póvoas et al. (2017) have shown that recreational team handball practice is an accessible, high-attendance, high-adherence exercise mode with physical and physiological demands similar to the elite version and in the range of those found to positively impact on aerobic, anaerobic, and musculoskeletal fitness in adult individuals. Team handball matches activity profile comprises numerous high-actions that highly tax the anaerobic metabolism and the muscles and bones, involving also a high aerobic component with mean heart rates (HR) of 82%HRmax. Therefore, training studies using recreational team handball as a health and fitness enhancing exercise mode are necessary. Menopause is associated with the loss of bone and lean tissue mass, muscle weakness and increase in body fat that can be counteracted by exercise (Borst, 2004; Engelke et al., 2006; Rosen, 2005). In postmenopausal women, high-impact or weight bearing exercise has shown to be effective in increasing areal BMD (Zhao, Xu, & Zhao, 2015) and changes in bone turnover markers

are evident up to 8 weeks after both aerobic and anaerobic exercise (Evans et al., 2008; Woitge et al., 1998). Hence, physical exercise has been recommended as a preventive and therapeutic strategy against aging-induced bone weakness (Schwab & Scalapino, 2011), although osteogenic responsiveness to mechanical loading declines with age (Lanyon & Skerry, 2001). Exercise is also effective in increasing muscle strength and cardiorespiratory fitness and decreasing fat mass in this population (Klonizakis et al., 2014; Mandrup et al., 2017).
Therefore, this study aimed at examining the physiological demands and musculoskeletal and cardiovascular fitness effects of a short-term recreational team handball-based exercise programme on sedentary postmenopausal women with no previous experience in the sport.

Methods

Thirty-five participants (66.4±6.1 years; 158.0±6.3 cm; 65.6±10.0 kg and 38.0±10.2% fat mass) were randomized into intervention team handball group (THG; n=20) or control group (CG; n=15). During 16 weeks, the THG participants performed 2-3 60-min sessions per week of a recreational handball training programme consisting of a standardized 15-min warm-up focusing on muscle strength, balance and coordination, followed by three 15-min parts of small-sided games, interspersed by a 5-min half-break. The CG maintained their usual daily physical activity.
Blood pressure, VO_2max, Yo-Yo intermittent endurance test – level 1 (YYIE1) and whole-body dual-energy X-ray absorptiometry-scans were performed at baseline and at 16 weeks. Blood pressure was measured by an automatic upper arm blood pressure monitor (Multi-parameter patient monitor, Omron Z207, Kyoto, Japan). Whole-body dual-energy X-ray absorptiometry (Hologic Explorer QDR, Hologic Inc., Bedford, MA, USA) was used to access BMD and body composition. The Bruce treadmill protocol (American College of Sports Medicine, 2013) was used to determine VO_2max (Oxycon Pro Metabolic Cart, Jaeger, CareFusion, Germany) and the YYIE1 (Bangsbo, 1994) was used to evaluate intermittent-exercise performance.
To determine the training sessions intensity, the participants' HR was monitored (Firstbeat Technologies Ltd., version 4.5.0.2, Jyväskylä, Finland) and rate of perceived exertion (RPE) was recorded 30-min after the end of all analyzed matches, using Borg's RPE category ratio 10-scale (CR10) modified by Foster et al. (2001).
The results are presented as mean±standard deviation (SD). The differences between the groups at baseline and at post-intervention were examined using a two-way analysis of variance (ANOVA) for repeated measures, with Bonferroni post-hoc multiple comparison tests. Statistical Package for the Social Sciences (SPSS Inc, version 23.0) was used for all analyses. The data were tested for normality using the Shapiro-Wilk test. Statistical significance was set at $p \leq 0.05$.

Results

Mean HR was 78±5%HRmax, peak values were 88±4%HRmax and HR was >80%HRmax for 49±23% of total match duration. Rate of perceived exertion was 5.6±1.8 (AU, 0-10). After 16 weeks of training, the THG increased (p=0.01) VO_2max by 9% (25.2±3.5 vs. 27.2±3.5 $mL.min.kg^{-1}$) and YYIE1 performance (p<0.001) by 93% from 238±84 to 461±249 m. Both groups showed a significant decreased in systolic blood pressure (THG: 124±15 vs. 116±13; CG: 134±17 vs. 121±20 mmHg; p<0.003) and fat mass (THG: 36±6% vs. 34±6%; p<0.001; 38±5% vs. 36±6%; p<0.001; p<0.03), but only the THG decreased total body mass (65.5±10.9 vs. 64.3±10.1 kg; p=0.03). No significant differences were shown in muscle mass, and only the THG showed an increase in lumbar spine (1.6%) and hip neck (2.1%) BMD (p=0.01).

Conclusions

Recreational team handball practice has positive effects on cardiovascular fitness, lumbar spine and hip BMD and body composition for postmenopausal sedentary women with no previous experience with the sport.

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THE CENTRE BACK PLAYER IN HANDBALL DURING ORGANIZED ATTACK-ANALYSIS OF THE MEN´S WORLD CHAMPIONSHIP 2017

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Summary
In recent years, Handball has evolved in such aspects of the game as technical tactical level, speed and rules. With this evolution the play and role of the specific positions in attack seems to be changing, with the centre back more dinamic and appearing in others zones of the field. We intend to analyze the centre back player and its influence in high-level team handball, looking for behaviour patterns in the four best ranking teams during the Men´s World Championship 2017.

Keywords: Team Handball, Centre Back, Observational Methodology, Polar Coordinates.

Introduction
Over the last decades Handball evolution has been noticeable and accentuated, providing changes in the approach of the game, determining a constant search, by the researchers and coaches and athletes, for everything that can be associated with success (Sousa, Prudente, Sequeira, López-López y Hernández-Mendo, 2015). The difficulties in assessing team and player performance continue to exist, in addition to the lack of literature related to this subject, despite the increasing increase in handball studies, revealing a relentless pursuit of the problems that arise in the game, and the coaches seeking answers that lead them to find a relationship to help achieve success. It is our opinion that, throughout this evolutionary process, the players underwent transformations and adaptations that allowed an improvement not only of the game, but also in several situations, like the specific positions of the attack, namely the centre back, that changed to a more in-depth role. However, there is no "standard" for the players who occupy this position, there´s even an heterogeneity by the various elements of this specific position of the main teams that present different characteristics, as well as the personal characteristics of the players. This situation led us to think that it is pertinent to study the influence of these players in the offensive game of their teams. With this study, we intend to analyze the role of the centre back and its influence in high level handball, looking for patterns of behavior in the four best teams of the 2017 Men's World Championship, relating this influence with their participation in the offensive transition and with the organization or not in the organized attack. With this investigation, we want to contribute to improving the knowledge of the offensive process of men's handball at the highest level and understand the importance of the role of the centre back in the attack eficacy.

Methods
Design
It has been analyze all the situations of game that occurred in the attack, during the games observed of the Mens World Championship 2017. We studied the behavior of the players of the specific position centre back in an offensive sequence. The observational design is in quadrant I, of ideographic character (is observed a unit), multidimensional (a mixed system of field format and system of categories was used), follow-up (the sequences are observed in several matches during the competition) and the data used are type I (sequential / base-event) (Anguera, Blanco, Hernández-Mendo y Losada, 2011).

Participants
Twelve games were observed both in the preliminary and final phases. Each team has been observe in three games. All the attack sequences were recorded, where there were 642 game situations (n = 642) registed from the various games. As an exclusion criteria, we removed all situations whose nonobservability period was higher than 10% (Anguera, 1990).

Instruments
With the aim of observing and game analysis, a mixed ad hoc instrument, field format with category systems, was created, validated and subsequently used, to record and collect data. This instrument had as main criteria the registration of offensive sequences using the program HOISAN, v1.6 (Hernández-Mendo, López-López, Castellano, Morales-Sánchez y Pastrana, 2012), which allows to perform the data quality analysis and exportation of the records for the SDIS-GSEQ program (Bakeman and Quera, 1996, 2011) for the sequential analysis. In addition, HOISAN allows performing sequential analysis with the polar coordinates technique.

Procedure
Data Quality
One of the basic requirements in Observational Methodology is the control of data quality (Blanco and Anguera, 2003), in order to detect and reduce the sources of error, without any situations that could compromise the investigation (Anguera and Blanco, 2003; Anguera, Blanco, Losada y Hernández-Mendo, 2000; Blanco and Anguera, 2003, Hernández-Mendo and Molina, 2002). To analyze data quality, Cohen's Kappa (1960) was used to assess intra and interobserver agreement. The values obtained (between 0.82 and 1.00) were considered excellent, since according to Bakeman and Gottman (1989) values above 0.70 are considered optimal. These values are due to the experience of the observers, since both had experience as handball coaches and had carried out Masters or PhD on the game using the observational methodology, which both dominate. Observers also met before and observed matches of the 2014 Men's European Championships in order to practice observation and discuss to achive consensual regist of behavior.

Development
Results and Discussion
The polar coordinates technique allows us to make a vector map and to locate the vectors in the various quadrants (I, II, III, IV), determining their angles, in order to establish a relationship between the focal conducts and the conditioned conducts used for each analysis. In this technique, that uses both prospective and retrospective analysis at the same time (Hernández Mendo, 1999), the size of the vectors determines the strenght of the relationship, in other words, the longer the vector the stronger the relationship.

In our analysis, we used as focal conducts the transition (1st Pass, 2nd Pass, No Participant, No Transition) and Attack Organization (Verbal Organization, Sinaletic Organization, Verbal and Sinaletic Organization, No Organization) and conditioned conducts The used way of finalization (Shot after drible, Shot after feint, Assist, Break pass, No shot, No relevant) and the result of the finalization (Goal, No Goal, No Shot, Goal by 7 meters, No Goal by 7 meters).
Considering the "First Pass" as focal conduct and as conditioned conducts the result of the Finalization, we obtained the results that are verified in Figure 1.

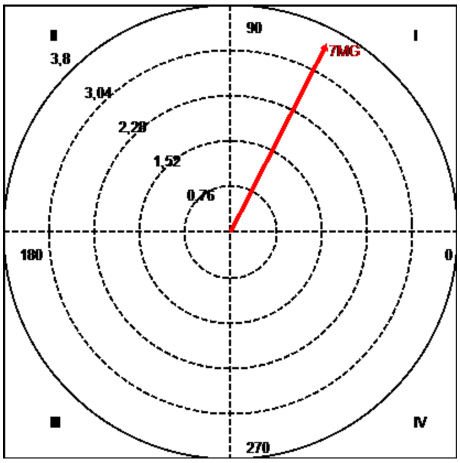

Figure 1. Vectorial map that expresses the interrelations between the focal conduct "First Pass" and the result of the finalization.
Subtitle: 7MG - Goal by 7 meters.

According to the obtained results, it is significant the relation of activation of the Given conduct 7m Goal (3.51).
The focal conduct "Second Pass" (when the centre back received the second pass in the offensive transition) , was also analysed, with conditioned conducts the ones refered as result of the finalization. As can be seen (Figure 2) there is one association relation. Thus, is significant the probability of the focal conduct activate the conditioned conduct NR (No shot) (1.98).
As we can see in results, there is a difference when the centre back participate in the first pass comparing with the situation he participate only in second pass: in the first case the attack ends with a goal from 7m and in the second case, theres is no finalization of the attack with an attempt to score a goal. It seems that more earlyer the participation of the centre back in the transition phase of attack more efficacy is obtain

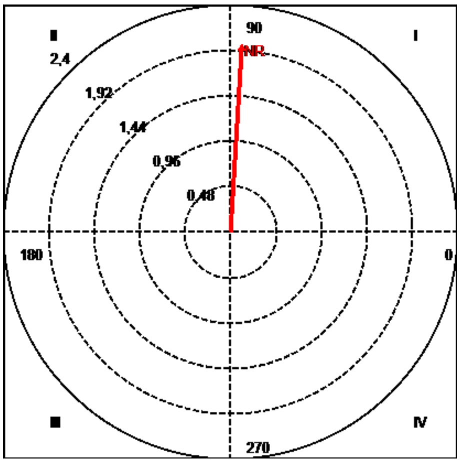

Figure 2. Vectorial map that expresses the interrelations between the focal conduct "Second Pass" and the result of the finalization.
Subtitle: NR - No Shot;

The way in which the centre back normally organized the attack was also studied. We took the focal conduct "Sinaletic Organization" and relate it with the result of finalization. As can be seen (Figure 3) there are many association relations. It´s significant the probability of the focal conduct activate the conditioned conducts Goal (3.73), Shot after Drible (2.46). This focal conduct also shows that the probability of inhibiting conditioned ducts is significant - No Shot (3.22) and Goal by 7 meters (2.98).

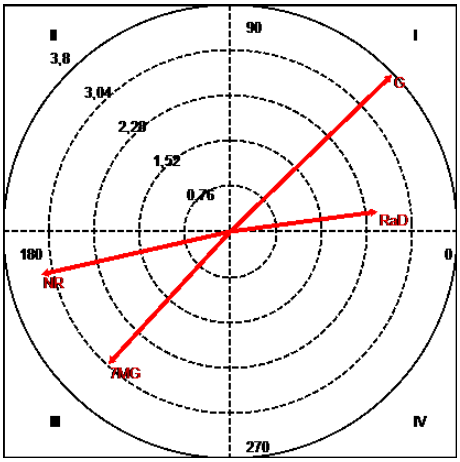

Figure 3. Vectorial map that expresses the interrelations between the focal conduct "Sinaletic Organization" and the result of the finalization.
Subtitle: RaD - Shot after drible; G - Goal; NR - No Shot; 7MG - Goal by 7 meters shot.

When we performed the polar coordinates analysis, having as focal conduct "Verbal Organization", we detected too some results (Figure 4). There is an activation relation with RS (3.34), with SR (2.78) and with NR (2.87) and inhibition of G (2.85), RaD (2.43) and PR (2.7).

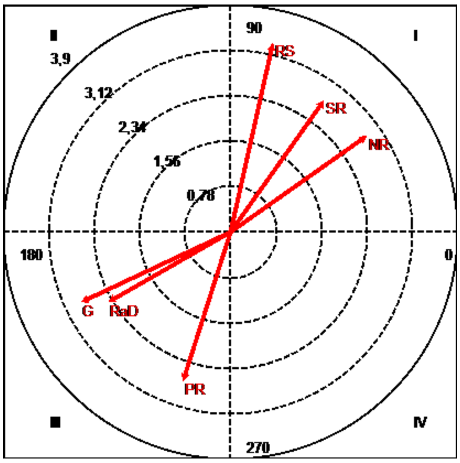

Figure 4. Vectorial map that expresses the interrelations between the focal conduct "Verbal Organization" and the result of the finalization.
Subtitle: RS - Simple Shot; SR - No Revelance; NR - No shot; G - Goal; RaD - Shot after drible; PR - Break Pass.

When we started from the focal conduct "Sinaletic and Verbal Organization", we detected three significant associations. According to the results obtained, the inhibition relation with the "SR" (2.54). Likewise, the probability of focal conduct to activate the "7MG" (2.31)and "PR" (3.56) behavior is significant, with this last one beeing the most intense relation (Figure 5).

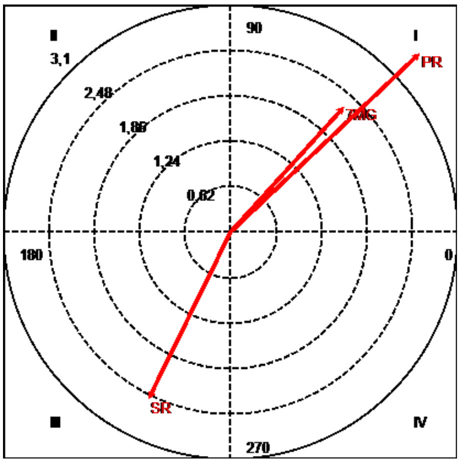

Figure 5. Vectorial map that expresses the interrelations between the focal conduct "Sinaletic and Verbal Organization" and the result of the finalization.
Subtitle: PR - Break Pass; 7MG - Goal by 7 meters; SR - No Revelance.

The results on Fig. 3, 4 and 5 show the importance of the centre back in the attack organization and the diference between using only sinaletic, hiding from the opposition, the intentions and actions. The efficacy of attack is associated with organization with sinaletic or with verbal and sinaletic than only with verbal organization.

The main results of the polar coordinates analysis shows that is significant the probability of:

1) The unorganized attack being associated with failure, specifically with ball loss;
2) The attacks organized by the centre back with signals or verbally are positively associated with success situations such as goal, break pass or the occurrence of 7 meters;
3) In the offensive transition, when the centre back receives the first pass activates the possibility of the occurrence of 7 meters;
4) When the centre back receives the second pass or does not participate in the transition, it is associated with failure, namely the inexistence of shot.

Conclusions

This study aimed to analyze the role and influence of the centre back in the team's offensive game, relating this influence with their participation in the offensive transition and with the organization or not in the organized attack, looking for patterns of behavior in the four best teams during the 2017 Men's World Championship. After this study we can verify that the influence and the actions of the centre back are associated not only to the offensive transitions, but also to the organized attack.

The results showed that the influence of the centre back is more evident in the games that he takes part in the offensive transition, receiving the first pass since, in those cases, there is a positive association between that and occurence of 7 meters. The results also show that, in the organized attack, when he organizes it verbally or with sinaletic there´s a significant possibility of sucess.

In previous studies, we verified the importance of the relations 2x2 in the attack (Sousa, Prudente, Sequeira, López-López, Hernandéz-Mendo, 2015), as well as the importance of defensive retreat (Sousa, Vieira, Cardoso, Prudente, 2017). However, in this study, the data reinforce the growing influence of the centre back in high-level male teams and point to a higher success situation the greater the influence of the players that play in that specific position, namely in the offensive transition and the organized attack. These results reinforce a reflection by the coaches in the training orientation, taking into account the evolution and tendencies of the current handball in the different contexts of the offensive game, namely the specific positions of the attack, considering the necessity to the participation of this player on defence, because of its importance in transition phase.

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TRAUMATIC AND ATRAUMATIC ACUTE COMPARTEMENT SYNDROME RHABDOMYOLYSIS IN SPORTS: RECOGNITION AND MANAGEMENT

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Summary
The experience of a fulminant femoral compartment syndrome without real causal trauma has led to an intense exploration of the pathophysiological model of this disease. It has been shown that a compartment syndrome without massive trauma occurs easily and has close parallels to the clinical picture of rhabdomyolysis. For both diagnoses, it is crucial that the doctor knows the disease and thinks about the possibility of existence. A wood-hard palpation in comparison and a modified two-point distinction distal to the body disorder have a real significance for the clinical diagnosis of compartmental diseases. Conspicuous creatine kinase (CK-MM) levels and discoloration of the urine in combination with unclear muscle pain should always be thinking of rhabdomyolysis. Those who understand the pathophysiology, may be able to act therapeutically successful in doubt.

Keywords: Compartment syndrome, rhabdomyolysis, similar pathophysiology models

Introduction

The clinical picture and thus the diagnosis of an *acute compartment syndrome* (ACS) is familiar to the orthopedic surgeon. He has to learn early that especially after each fracture of a long bone, an ACS can be a typical complication and that precisely this complication must be regularly excluded. The ambitious sports physician is more likely to be confronted with the *exercise induced acute compartment syndrome*, also known as *chronic compartment syndrome* (CCS) which is clinically seen as recurrent pain after endurance exercise.

An acute thigh compartment syndrome - without adequate trauma, which had to be diagnosed and treated at a German top athlete, in the context of the Olympic Games 2016 in Rio de Janeiro, was the reason to present this case and to investigate the pathogenesis of this disease on the basis of the literature.

The following factors should be emphasized: 1. A compartment syndrome does not necessarily have to be associated with a truly adequate trauma. 2. Parallels to the pathomechanism of rhabdomyolysis, a disease that can also be observed in the sports environment, must be considered. 3. There are reliable indicators for a self-entertaining Circulus vitiosus. All this factors makes the diagnosis, more "not to miss a true diagnosis" more difficult.

It should be emphasized at this point, that successful therapeutic concepts for both forms of disease must break or ideally prevent the self-sustaining and reinforcing influencing factors.

Case Report

As part of the 2016 Olympic Games, a 25-year-old handball player, who was classified as completely healthy, completed a normal competitive match. At the end of the game, there was no evidence of injury or physical strain beyond the expected level. As part of the regular follow-up on the evening of the match day, the player reported for the first time of "problems in the thigh muscles of the left leg". Despite the request, no "real pain" was confirmed by the athletes. The player who regularly does not take any medication was purposely left for the next night without medication. On the morning of the following day, the player reports about repeatedly sensory disturbances on the left foot and lower leg during the night. The clinical examination, about 16 hours after the end of the game, revealed a significant increase in the size of the left thigh when compared to the right side. In addition and beyond doubt, a hard tissue consistency of the extensor thigh musculature on the left side had to be palpated. As expected, the pulse of the dorsal artery of the pedis was well palpable. At the same time, a new pronounced joint effusion in the left knee surprised us. The contralateral right leg remained clinically normal.

Under the suspicion of an ACS, a magnetic resonance tomography (MRI) of the left thigh and knee joint was carried out in the Olympic Village, within a very short time. MRI shows massive thigh compartment syndrome. Due to lack of consequences, we have omitted some other form of investigation. Without any further loss of time, means under full emergency conditions, all thigh compartments of the left leg were surgically opened at the Olympic Games accredited hospital in Rio de Janeiro. The resulting femoral wound was sealed intraoperatively, also for transporting the athlete to Europe, with a vacuum bandage. The athlete returned to Germany. As part of further surgical interventions, the wide-open wound of the thigh has been reduced in several operations and finally closed secondarily. The ACS healed without permanent functional limitations. The athlete could return after about 6 months as a player in the 1st first handball league.

Definition: compartment syndrome

„A compartmental syndrome is defined as a condition in which increased pressure within a space compromises the circulation to the contents of that space. Any cause of increased intracompartmental pressure may result in a compartmental syndrome.“ The definition of compartment syndrome published by Matsen [21] in 1975 is already relatively comprehensive.

The prerequisite for the development of a compartment syndrome is a solid and intact anatomical covering wherein the non-elastic sheath completely surrounds the affected tissue [15].

"If the non-physiological pressure within a compartment impaired neuromuscular function", this is a more precise definition of compartment syndrome [4].

One reason for a compartment syndrome may be a reduction of the chamber volume due to external pressure, for example. Alternatively, but also an increase in the chamber contents, for example, as a result of bleeding or a permeability disorder of capillaries and a resulting edema. The result of both principles is completely identical. There is a discrepancy between the capacity need and the available capacity, and thus a compartment syndrome. However, a reliable relationship between the extent of the trauma and the development of a compartment syndrome is not clear upon closer examination. Even if a system failure occurs, it can regress spontaneously and without consequences - how this can be observed in chronic compartment syndrome of the athlete. In the same way, however, the emergence of ACS with the associated risk of irreversible muscle necrosis can result [33] to the clinical picture of rhabdomyolysis.

Incidence and etiology

In 36% of his cases Andrew Duckworth recognized a context between an acute compartment syndrome and a acute bone injury, such as a tibial shaft fracture.[5] From the same author, in 23% of cases, there was an isolated tissue trauma - without fracture - responsible for the development of ACS. [5] In addition to bone fractures and blunt muscle injuries, the consequences of burns and electrical accidents [18, 31] and reperfusion edema after storage or pressure-related reduced perfusion are described as decreasing frequencies [42].

The risk of suffering from ACS, is in open and closed fractures identical [25, 44]. Andrew Duckworth pointed out that, compared with both sexes, men under the age of 35, with an incidence of 7.3% compared to 0.7%, are 10 times more likely to be affected by ACS than old women [5]. In the literature is the particular danger to young men to develop compartment syndrome, widely recognized [26, 41, 42, 44]. McQueen explains this higher risk for young men with a relative imbalance between increased muscle volumes on the one hand and a compartment size that does not change over growth. Especially young men have less space for an injured and potentially swelling muscle [26].

Older people with a decreasing muscles are better protected. Even a possibly existing arterial hypertension has a protective effect on the development of ACS. A chronic arterial hypertension is associated with a higher tolerance of the tissue and here also of the peripheral nerves to increased tissue pressure [8, 47].

The ACS is to be distinguished from the chronic compartment syndrome (CCS). The latter is observed as a recurrent clinical syndrome after exercises. Chronic compartment syndrome

is characterized by a good spontaneous regression trend. Just to remind - clinical symptoms associated with ACS or CCS must be distinguished from pain in a Shin splint syndrome and stress fractures.
CCS is characterized by painful conditions that can subside when the physical strain is stopped. However, these symptoms usually return when the activity resumes. However, as in the case of an acute compartment syndrome, no one can estimate, whether the symptoms of a chronic compartment syndrome are really calming down or leading to a clinical disaster. In the literature cases of compartment syndrome can be found at every level of trauma.
Worasak Jaichalad et al. published the development of a lower leg compartment syndrome with complete removal of the long peroneal muscle as a result of isolated ankle distorsion [48].
Kowalewski published in 2009 the case of a football player, this athlete, as in our case, allegedly developed an acute compartment syndrome without apparent trauma [14]. There is a publication describing a 7-hour journey with car as the cause of an acute (atraumatic) compartment syndrome of the lower leg. [34] A wealth of similar literature [1, 2, 3, 16] confirms this thesis.
When analyzing possible complications in the description of acute compartment syndrome, the terms "crush syndrome" and "rhabdomyolysis" are recurrent. According to Walker [45], advanced compartment syndrome can lead to rhabdomyolysis. Rasul [35] shows that as a complication of primary rhabdomyolysis a secondary compartment syndrome may occur.

Heppenstall et al. suggest that the difference between *perfusion pressure* and *tissue pressure* plays a dominant role in the pathophysiology of compartment syndrome both experimentally and clinically [9]. Arcot Rekha [36] describes the compartment syndrome as a condition that occurs in a closed anatomical space. Here among the pathologies that the perfusion pressure falls below the tissue pressure.
A mathematical model calculates tissue perfusion via the term "local blood flow" LBF. The following parameters are to be considered in the pathophysiological model of compartment syndrome: local *blood flow (LBF)*, local *arterial pressure (PA)*, local *venous pressure (PV)* and local *vascular resistance (R)*. Tissue perfusion is calculated by the formula **LBF = (PA-PV) / R**.
This means that tissue perfusion is equal to the difference between arterial and venous pressure, divided by the vascular resistance.
An increasing pressure in the compartment space also boosts the local venous pressure. Increases the venous pressure, the arteriovenous pressure difference must decrease. Thus, the main driving force for tissue perfusion is weakened. [6, 22]. Crucial for cell damage are mechanisms that either increase the venous pressure and tissue pressure or reduce the mean arterial pressure. The interaction between these opposing forces determines the outcome of the patient. The degree of damage observed and to be treated is the result of a dynamic relationship between compartment pressure level, exposure time and, at the same time, the patient's blood pressure [20]. Rekha [36] emphasized in her pathophysiology the dramatic effect of a vicious cycle. She point out the context between the rising intrakompartmentalen pressure and the result of an increase in venous pressure and an associated collapse of the capillaries with reference to a 1983 published work of Mubarak [29].

The following figure shows the relationship between a pressure increase in the compartment and a resulting muscle cell damage. At the same time, the continuing vicious circle is visible.The now presented pathophysiological model was published in 1983 by Mubarak [29].

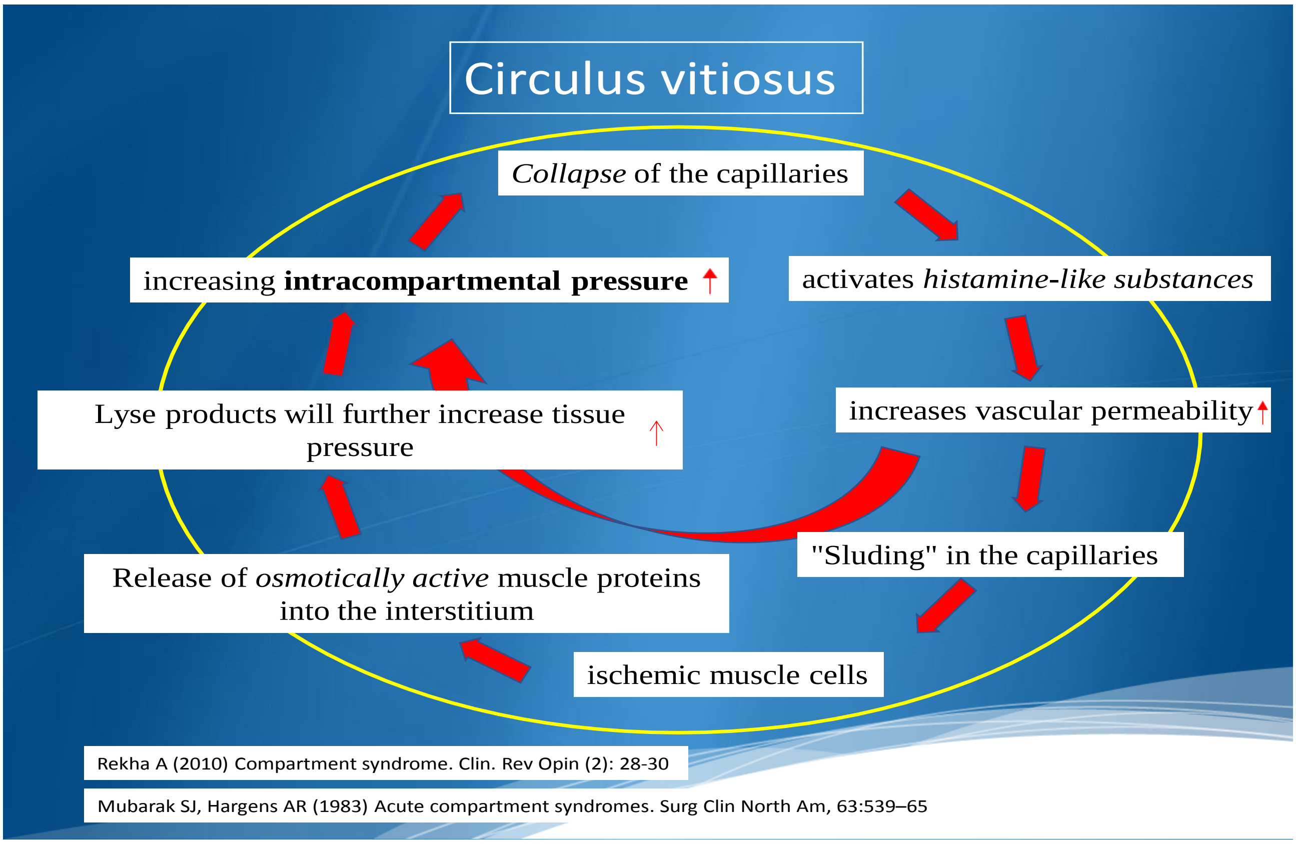

Figure 1: Devil circulation from tissue pressure increase and muscle cell damage

The histamine-like substances increase the vascular permeability. The capillaries lose as a result of this change plasma into the surrounding tissue. Consequently, the viscosity in the small capillaries must increase, further aggravating ischemia. As a result of ischemia, the myocytes (muscle cells) disintegrate. Crumbled muscle cells not only generate myofibrillar proteins with glycogen and myoglobin, but also osmotically active particles. Osmotically active particles in addition extract water from the capillary. This effect inevitably increases the interstitial pressure. This interstitial edema increases the diffusion distance for oxygen and results in increased acidosis. A shift of the tissue ph into the acidic area (increased acidosis) increases the vascular permeability - an increase in edema is the result - also in this sector a vicious circle [7].
Rasul [35] describes the following relationships: When interstitial pressure within a closed tissue compartment exceeds the capillary perfusion pressure, tissue perfusion is reduced by collapse of the capillaries, resulting in tissue ischemia and muscle cell death.
Crumbling myocytes release osmotically active substances. The increase in a closed compartment of one milliosmole (mOsm) causes a further increase in intramuscular pressure of 19.5 mmHg. The vicious cycle is preserved. If the tissue blood flow continues to decrease in this context, is muscle ischemia and subsequent cell edema [35] worse. Customary autoregulation operations to maintain the tissue perfusion by an altered vascular resistance, do not seem to work stabilizing [40].

The now presented pathophysiological model was published in 1983 by Mubarak [29]. It was confirmed in the 2000s by Mühlbacher [30], Elliott [6] and Frink [7] and transferred to a biochemical and energetic level by Via et al. [44] and Frink et al. [7] . They also confirm the self-entertaining processes. They point out that the lack of circulation leads to a local lack of energy. In this context, potassium and myoglobin are released by the breakdown of myocytes in dangerous amounts.

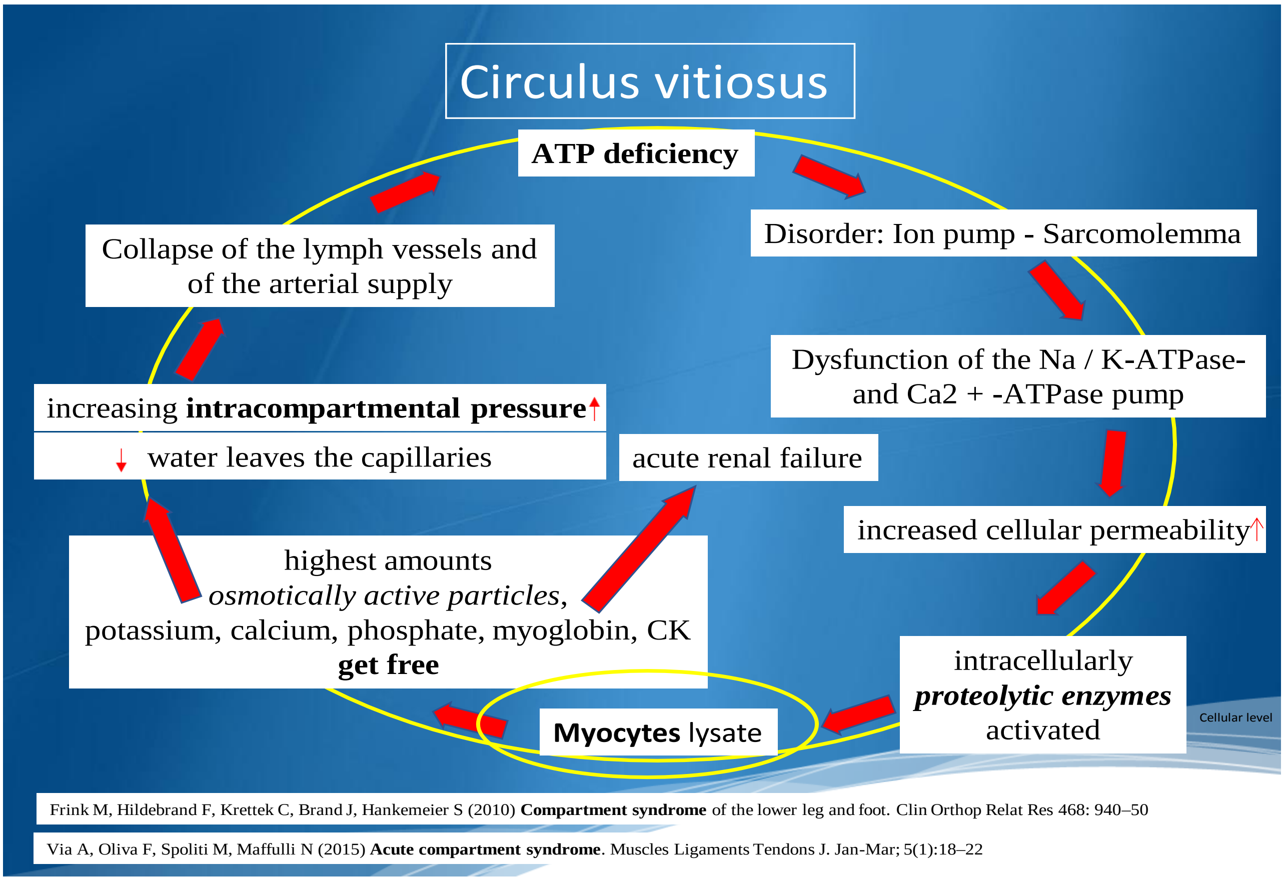

Figure 2: Unphysiologically high compartmental pressures - energy deficit - muscle cell death - and acute renal failure

Similar to observations in compartment syndrome, the destruction of muscle cells and the associated flooding of the circulation with "myocyte components" also play a crucial role in the pathophysiology model of rhabdomyolysis. In the case of an energy deficit [ATP (adenosine triphosphate) deficiency], the ion pumps in the sarcolemma have problems maintaining the distribution of electrical charge and maintaining the electrolyte differences. A depletion of ATP concentration results in a malfunction of the Na / KATPase- and Ca2 + -ATPase pump. In the case of a massive failure, this results in an increased cellular permeability to sodium ions and / or an unphysiological increase of intracellular calcium. There are activated intracellular proteolytic enzymes that degrade the muscle cell. From the crumbling myocytes large amounts of potassium, aldolase, phosphate, myoglobin, creatine kinase (CK), etc. are released into the circulation. As a result, acute renal failure [10, 11, 13, 17] is possible.
In the context of muscle injuries, in addition to electrolytes, large amounts of myoglobin and CK are released. Under physiological conditions, the plasma concentration of myoglobin is very low at 0-0.003 mg per dl. If more than 100 grams of skeletal muscle are damaged, the serum haptoglobin-binding capacity is already saturated [13]. The circulating excess myoglobin filtered in the kidney may precipitate in the renal glomerular filtrate, leading to a renal tubular occlusion [19, 32, 38, 43].

Sauret et al. [38] confirms that muscle injuries, regardless of the mechanism, trigger a cascade of events. Sauret stresses in this context a shift of extracellular calcium ions into the intracellular space. The authors transfer the familiar vicious circle of compartment syndrome to the clinical picture of rhabdomyolysis. The excess calcium causes a pathological interaction of actin and myosin, which causes muscle destruction and fiber necrosis. As the following figure shows, potassium can be released alongside calcium in large quantities. In a rapid release of intracellular potassium malignant cardiac arrhythmias can be triggered [46].

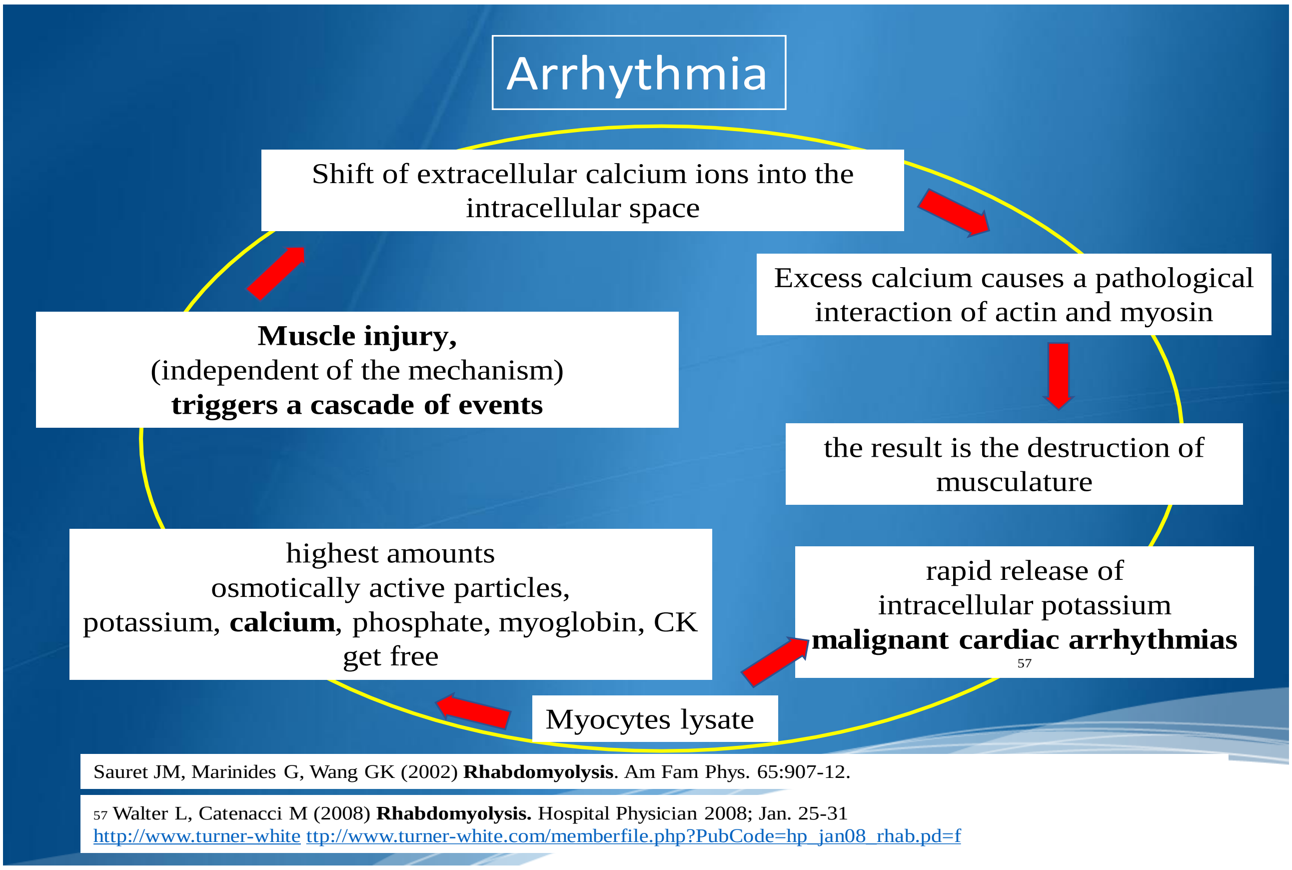

Figure 3: Muscle cell death - acute heart failure as an early complication of rhabdomyolysis

The comparison of the above figures should show, that there are clear parallels between the pathophysiological models of compartment syndrome and rhabdomyolysis.

According to Walker [45], advanced compartment syndrome can lead to rhabdomyolysis. Conversely, Rasul [35] shows that rhabdomyolysis induces a secondary compartment syndrome. Keltz [12], Rasul, [35] and Miller [28] also show a direct relationship between the presence of rhabdomyolysis and the induction of acute compartment syndrome. Accordingly, the compartment syndrome may be regarded as an early or late complication of rhabdomyolysis [38].

The task of the physician

Matsen [21] points out that in any case where the doctor see a patient with unclear pain or a neuromuscular deficit in a limb, the possibility of compartment syndrome should be considered. If "signs of circulatory disturbance of nerves and muscles associated with increased pressure in the compartments" are added, the diagnosis is even more likely.The earliest possible diagnosis of compartment syndrome and at the same time a consistent treatment are of utmost importance to avoid poor treatment results [21, 25, 27, 37, 39]. Also for McQueen [26], "awareness of the possibility" is the most important factor for early diagnosis of acute compartment syndrome by medical staff. In a delayed diagnosis or if the therapy is incomplete, serious consequences threatened. Loss of function of the affected limb or even death of the patient with multiple organ failure is possible [23].

Clinic compartment syndrome

Patients typically complain of deep pain and a feeling of tension in the affected extremity, its severity appears not to be proportional to the accused injury. The complaints are worse for passive stretching of the muscles involved. However, pain should not be a sine qua non of diagnosis. The most important diagnostic physical finding is a massive feeling of wood with deep palpation of the affected muscles. In the page comparison this finding should not be overlooked. If a reduced two-point discrimination needs to be demonstrated, this should be considered a reliable early test. The often recommended compartment pressure measurement [24] is error-prone and does not release the responsible physician in cases of false negative measurement results.

Clinic rhabdomyolysis
Clinical features of rhabdomyolysis are local muscle pain, tenderness and swelling of the limb. First systemic features can be a tea-colored urine along with fever and general malaise. Hyperkalemia, hypocalcaemia, arrhythmia, and cardiac arrest are classified as early complications, acute renal failure, disseminated intravascular coagulation, and compartment syndrome as late complications [38]. The enzyme creatine kinase (CK) is present ubiquitously in striated muscle. When muscle cells disintegrate, the enzyme CK is released into the bloodstream. In the striated muscle CK-MM and located in the heart muscle subtype CKMB is. During rhabdomyolysis extremely high levels of CK-MM are released. So are possible with a CK-standard value of <170U / l for an adult male fall ill, peak concentrations of 10,000 to 100,000 U / l.

Treatment compartment syndrome
The most important aspect of successful therapy is to think primarily in the possibility of an acute compartment syndrome. The treatment of choice for ACS is early and complete decompression of the affected muscles. This fasciotomy is performed surgically as part of an urgent emergency operation [25].

Treatment of rhabdomyolysis
As has been demonstrated, the pathogenesis of rhabdomyolysis is also based on a vicious circle. The mutually negative influence processes on different levels of the body, making the treatment of a severe form extremely complicated. A patient should already be monitored in case of suspicion multidisciplinary under the leadership of a department on a powerful intensive care unit of a hospital and treated.Not even basic features of a successful therapy can be addressed in this publication. However, it should be clearly stated that in spite of correct and timely diagnosis and a content unobjectionable therapy deaths as part of rhabdomyolysis are seen as fateful.

Take home message

- The observation of a fulminant femoral compartment syndrome without a reliable or adequate trauma led to the question of the pathogenesis of this disease. It has become clear that a number of causes can trigger a self-reinforcing vicious cycle. Under the same principles, at the cellular level, the disorder responsible for the symptoms of rhabdomyolysis and compartment syndrome should be sought.

- The pathophysiological processes make all clinical variants, from severe muscle ache to sudden cardiac death in a fulminant rhabdomyolysis explained.

- Disorders that are not subject to a clear dose-response relationship are problematic for physicians to recognize and even more difficult to treat.

- Given the potential morbidity, it is important to recognize the compartment syndrome early and treat consistently. The diagnosis is primarily clinical.

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RELATIONS BETWEEN PSYCHOLOGICAL FACTORS, PERFORMANCE AND INJURIES IN FEMALE TEAM HANDBALL

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Summary
The focus on psychological demands in team handball is growing continuously. Scopus yielded 108 results on „handball, psychological“, while the number of results per year rank-correlated positively between the first result in 1973 and the latest results in 2017 (ρ = 0.549). Also, when regarding the latest literature in sports medicine, a connection between handball-related psychological factors and injuries as well as return to sports seems likely.

Keywords: Handball, psychological factors, return to sports, positions, predisposition to injury

Introduction

The focus on psychological demands in team handball is growing continuously. As per July 2017, the database Scopus yields 108 results on „handball, psychological“, while the number of results per year rank-correlated positively between the first result in 1973 and the latest results in July 2017 (r = 0.549). This hints at a growing research-interest in psychological factors. Regarding the latest literature in sports medicine, a connection between handball-related psychological factors and injuries as well as return to sports also seems likely.

Literature research regarding performance-limiting psychological factors in team handball

For team handball, current literature names performance-limiting psychological factors (e. g. mental toughness), although only few studies have been undertaken so far. Mental toughness has to be seen as a multidimensional construct consisting of self efficacy, motivation, action-control (AC, action-oriented), tolerance for frustration, intensity and stress, mental endurance, self regulation, commitment, concentration and probably other factors (Gerber, 2011). It is likely that players have to be able to perform well under pressure, recover quickly from mistakes and tolerate frustration and pain while having the qualities of a fighter (Wegner & Dawo, 2012), so it is to be expected that mental toughness is performance-relevant in team handball. Its foundations are not yet clearly specified, although some of the mentioned factors seem to be linked to AC, motivation and volition. In other team sports like soccer volition is seen as a crucial factor for performance (Reinhardt, Löw, Savolainen und Welling, 2011), next to the ability to act fast and correct (Krause, Kärcher, Munz & Brack, 2012). Seidel (2005) found handball players to be more action-oriented than swimmers and track and field athletes while Brack (2002) expects differences between positions in AC (half backs being action-oriented shooters, centre backs being state-oriented playmakers) without having conducted a study. Gonçalves, Rama and Figueiredo (2012) claim psychological factors to be useful as a predictor of talent while at the same time Moesch, Hauge, Wikman & Elbe (2013) found volition to be a predictor for the development of talent. Lidor, Falk, Arnon, Cohen and Segal (2005) showed that physical tests were no selection-criterion for the national youth team of Israel. Since slalom-dribbling was crucial for selection, the authors surmise that cognitive skills might be relevant. Silva (2006) names several psychological factors to be important in team handball from his experience as an international coach without having conducted a study: motivation, will, ability to recover quickly after an error, anticipation, ability to deal with visibility on-court, court-sense, mental toughness, discipline and flexibility, dealing with anxiety, pain tolerance, self-confidence, mental endurance, ability to work for the team, optimism before matches and dealing with emotions. It has to be mentioned that although the performance-relevance of psychological skills is known to the coaches and there are studies concerning the improvement of performance after psychological intervention (Popa, 2006), a study of Reverter-Masía, Legaz-Arrese, Munguía-Izquierdo, Roig-Pull, Gimeno-Marco and Barbany (2008) showed that from 14 tested handball clubs not one club had a full-time sports psychologist while in soccer 40 % of the clubs were employing one. Some psychological factors have already been assessed in team handball players (Tab. 1). There are contradictory results regarding task- and ego orientation (TEO, Massuça, Fragoso & Teles, 2011; Massuça & Fragoso, 2013; Matthys, Vaeyens, Vandendriessche, Vandorpe, Pion, Coutts et al., 2011; Vasconcelos-Raposo, Moreira & Teixeira, 2013). Li & Chi (2007) found that perceived competence as well as precompetitive anxiety is likely to confound the effects of TEO. Players with high perceived competence will more likely interpret competitive anxiety in a way facilitative to game-performance, no matter whether their task- and/ or ego-orientation is high or low. TEO might therefore not be performance-relevant to team handball if not occurring together with a high perceived competence. In consequence, next to the highlighted factors in Tab. 1, perceived competence can be considered beneficial for handball-performance.

Most of the afore-mentioned studies refer to male players and do not distinguish between positions. However, there have been studies researching positional demands. Studies in other team sports show position-specific psychological demands for these sports (Grobbelaar & Eloff, 2011; Hughes, Caudrelier, James, Redwood-Brown, Donnelly et al., 2012; Widmeyer, Brawley & Carron, 2002), while for team handball there are only few position-specific studies (Tab. 2).

Kajtna et al. (2011) found that high-level goalkeepers function in a rather action-orientated way when it comes to coping with failures, while Vasconcelos-Raposo, Moreira & Teixeira (2013) named significant motivational differences at a global level between positions for male Portuguese players without being able to specify between positions via post hoc-test. Descriptive statistics showed higher levels of ego-orientation (EO) for pivots and lower levels of task-orientation (TO) for centre backs than on other positions. Vasconcelos-Raposo et al. (2013) found a tendency for differences between positions with Allrounders > Half Backs > Goalkeepers > Wings > Pivots > Centre Backs for TO and Half Backs > Pivots > Wings > Goalkeepers > Centre Backs > Allrounders for EO.

While psychological demands are seen as a factor which is crucial to performance for goalkeepers, the exact composition of a goalkeeper's psychological profile has not yet been specified (Kajtna et al., 2011). In addition, studies do not always test the relevant psychological factors. The study from Kajtna et al. (2011) contained no results for concentration, fear or aggression, but it was evident that successful goalkeepers did not think about failure as long as less successful goalkeepers. This could hint to a need for high action-orientation after failure on that position, but no need for a special development of the other factors tested in that study. More studies researching position-specific psychological demands profiles are necessary to be able to coach and select players most efficiently (Weber & Wegner, 2016).

In female team handball, only few studies regarding psychological characteristics (Sosa González, Oliver Coronado & Alfonso Rosa, 2011, 2013 a, b, c;), let alone on the different positions (Balykina-Milushkina, 2012, Čavala et al., 2013; Dorá & Ökrös, 2011; Leptien, 2009; Speicher, Kleinöder, Klein, Schack & Mester, 2006; Weber, 2014; Weber & Wegner, 2016; Weber, Wegner & Popa, 2016) have been undertaken so far, although it is to be expected that female players differ from males (Marczinka, 2011; Sosa González & Oliver Coronado, 2013 a, b) and positional differences are relevant to performance.

One particular factor which is connected to psychological aspects and which is showing differences between the positions is handedness. In team handball, right-handed players are often put on the left side of the court and left-handers on the right, since this leads to optimal ankles when throwing the ball at the goal (Oberbeck, 1989; Pohn, 2009). Among female Austrian players there are 88.2 % right-handed, 8.3 % left-handed and 3.4 % ambidextrous players, while the dominant hand mostly is the throwing-hand (Pohn, 2009). At the Handball-Supercup in 1987 there were up to three left-handers at a time on the court, which leads to a call for ambidexterity in handball players to ensure maximum flexibility (Oberbeck, 1992). Weber (2014) showed that on the different positions, players of different handedness are positioned in different percentages (Fig. 2), which partly also correlate with playing-level (left- and ambidexters on right wing; both- and left-handers on right back; ambidexters in the goal; no left-handers on the pivot-position; right-handers on centre back).

In goalkeepers, right-handedness correlates negatively with expertise. The fact that only right-handers are positioned on centre back can be interpreted as preference for right-handers on this position since even when considering estimated failure, the percentage of left-handers undercuts that in female population. Playmakers should be state-oriented while performing a task while this psychological characteristic is linked to right-handedness as well as high values in Self-optimizing. State-orientation while performing is crucial for right-handed players on several positions.

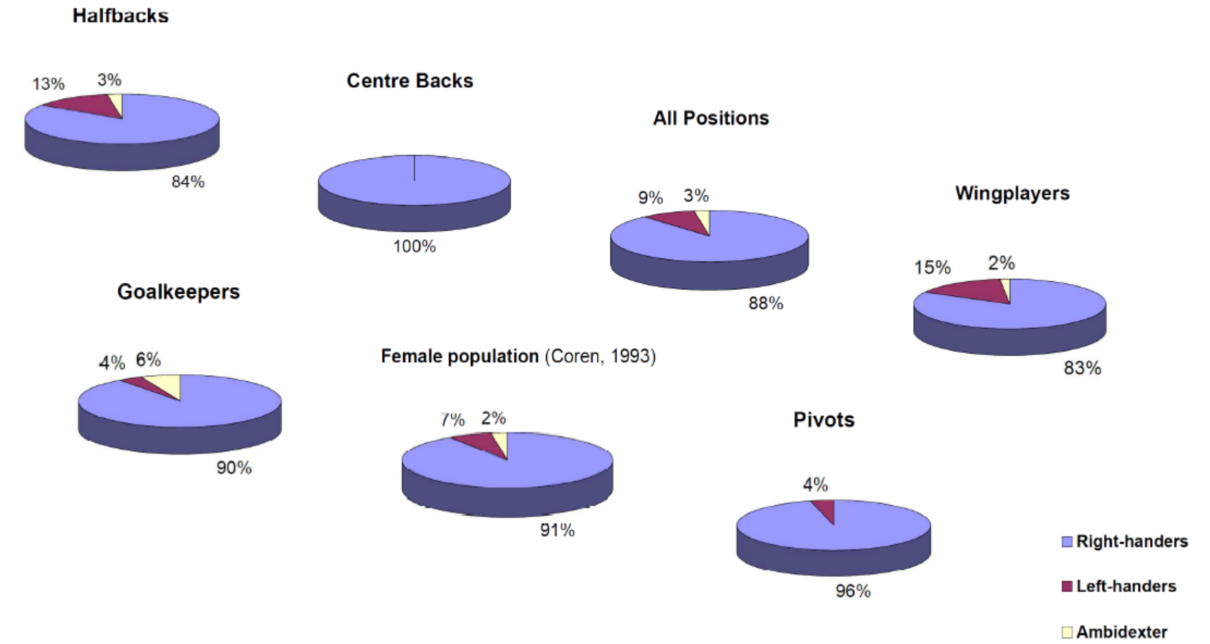
Tab. 1: Findings regarding psychological aspects in literature for male (m) and female (f) athletes.

Findings regarding psychological aspects	Study
TO and EO and direction of precompetitive anxiety are linked to self-perceived competence	Li & Chi (2007, m Chinese students)
Attention not related to expertise-level	Memmert et al. (2009)
Experienced Greek players act more aggressive while men have higher values than women.	Christoforidis et al. (2010, m, f)
Relation between anger, vigour and training load in male competitive players.	Bresciani et al.(2010)
Elite and non-elite players do not differ in task- and ego-orientation.	Matthys et al. (2011); Massuça et al. (2011)
Good results in Men`s Asian Games despite insufficient physical preparation, at the same time good results in the OMSAT3-questionnaire.	Shahbazi et al. (2011, Iran national team)
No difference of assertive level between male and female players, handball players are more extroverted than overall population.	Dorá et al. (2011)
Selected youth players had non-significantly better values in psychological questionnaires.	Schorer et al. (2008)
High TEO (TO slightly higher). Experienced players/ players playing longer for a club had higher EO.	Vasconcelos-Raposo et al. (2013, m)
High values for impulsivity, anxiety, aggression, sociability; low values for activity. Psychological intervention improved these values.	Berbecaru et al. (2015, m youth elite)
No success-related differences in Mental Energy, Athletic Engagement and Optimism, only age-related differences.	Sindik & Čuk (2016, m youth)
Concentration	Wegner (1994, m), Langenberg (1997, f)
Perception	Meyers (1997)
Anticipation, Motivation	Langenberg (1997, f), Büsch et al. (2008), Rivilla et al., (2011)
Ability to observe	Langenberg (1997, f), Zastrow et al. (2009)
Decision making	Langenberg (1997, f), Leptien (2009, f)
Situative determination, reaction, psychomotoric coordinative ability, operational readiness, stress tolerance and self-confidence	Langenberg (1997, f)
Improved attacking-performance after training psychic energy, direction of stress, aims, attention, concentration, mental imagery.	Martínez et al. (1998, male youth)
Personality traits in youth players	Seidel (2005)
Handedness	Pohn (2006), Oberbeck (1989; 1992)
Low results for dissimulation in elite players	Rogulj et al. (2006)
Intuition is related to expertise.	Raab et al. (2011)
Ability to vary actions	Massuça et al. (2013, m)
Ego-orientation	Massuça et al.(2013, m)
Volition (self-determination, not postponing training)	Moesch et al. (2013)
Low anxiety, high motivation and good adjustment to new situations	Sehgal (2013, f)
Mental skills according to the Psychological Characteristics Related to Sports-Questionnaire	Sosa González et al. (2013, f)
Task-orientation, collectivism, goal-orientation	Arraya et al. (2015, m)
Relations between psychological skills (mental toughness, coping, emotional control and confidence) and shooting effectiveness	Ragab (2015, Egyptian m university players)
Competitive Anxiety is related to Psychological Performance	Morillo Baro et al. (2016, beach handball)

Tab. 2: Position-specific psychological aspects.

Position	Performance-limiting psychological factors	Study
Wing	Relation to performance for hope for success, fear of failure, net hope, total achievement motive (high), self-impediment (high), lack of activation (low), loss of focus (low), AC after failure (low)	Weber (2014, f); Weber & Wenger (2016, f); Weber, Wegner & Popa (2016, f);
	High speed of decision making	Leptien (2009, f)
Half Back	Lowest results for psychoticism.	Dorá et al. (2011, m & f)
	Relation to performance for hope for success, total achievement motive (high), self-impediment (high), AC after failure (low) and AC while performing a task	(see wings)
Centre Back	Psychological stress tolerance can be assumed due to intensity of play.	Böttcher (1998, m)
	Relation to performance for self-optimizing and AC while performing a task (high)	(see wings)
Pivot	Psychological stress tolerance assumed due to intensity of play.	Böttcher (1998, m), Luig (2008, m), Manchado et al. (2009, f)
	Emotionally stable. Neuroticism level of m and f players does not differ significantly.	Dorá et al. (2011)
	Relation to performance for hope for success, net hope, self-impediment (low), loss of focus (by trend) and AC after failure (high by trend)	(see wings)

Goalkeeper	Anticipation expertise	Schorer (2007, m)
	More successful goalkeepers show slower response times in complex situations, simple selective tasks and complex tasks with visual orientation, but thought shorter about mistakes they had made.	Kajtna et al. (2011, m Elite Slovenia)
	Confidence, courage, instinct, concentration	Sá et al. (2015, m)
	Cognitive speed of action	Speicher et al. (2006)
	Lower scores in introversion-extroversion compared to other positions, more introverted.	Čavala et al. (2013, f youth elite)
	Best performance in Psychological Characteristics Related to Sports-Questionnaire.	Olmedilla et al. (2015)
	Relation to performance for hope for success (high by trend), net hope (high), self-impediment (high), lack of activation (low), loss of focus, AC after failure (low), AC when planning a task (low by trend) and AC when performing a task	(see wings)



(Confidence-interval 0.95 with d_max ± 2.15 %); WP = Wingplayers, HB = Half Backs, CB = Centre Backs, P = Pivots, GK = Goalkeepers

Fig. 2: Percentages of handedness on different positions and in female population.

Specialization for a position and position-specific selection concerning psychological factors is necessary and helpful in adult female players (Weber & Wegner, 2016), but psychological factors may change during puberty and specializing too early should be discouraged in order to ensure the right player is put in the right place. Psychological factors might be a better predictor than other performance factors, since conditional and constitutional factors are "*poor markers for sport-selecting strategies*" (Gonçalves, Rama & Figueiredo, 2012, p. 392). Motivation might be a predictor (Gonçalves et al. 2012) as well as volition (Moesch, Hauge, Wikman & Elbe, 2013). The "Long term handball development model" (Matthys, 2012) recommends specializing at 16 years of age for boys, whereas Čavala et al. (2013) recommend specialization at 13 for girls to promote optimum development of conditional and constitutional factors. Here, criteria for selection have to be discussed. Constitutional parameters and early selection are seen controversially (Matthys, 2012; Visnapuu & Jürimäe, 2009; Visnapuu, Jürimäe, Jürimäe & Allikivi, 2011 against early selection according to constitutional factors, Čavala et al., 2013 for selecting early according to constitutional factors) because those factors can change for youth players during puberty, possibly suiting them better to another position for which they then lack the technical and tactical components. Thus, specialization and selection according to psychological factors is a topic which probably should and most probably will be researched further in the following years.

Literature research regarding psychological factors and injuries

In team handball, frequent collisions between opponents, high tempo, rapid changes of movement and jumps with hard landings lead to a high risk to get injured. Studies from the Summer Olympics

2008 and 2012 have stated that team-handball shows one of the highest injury rates compared to other sports (Engebretsen et al., 2013; Junge et al., 2009). There are several joint movements, landings, contacts that bear noticeable injury risk. Internal risk factors include, for example, age, gender, previous injuries, physical fitness and psychological factors, while external risk factors include rules, regulations, equipment and floor type. In the comparison of injury rates in the German sport club system team-handball scored second after soccer with 2 injuries per 1000 hours of match (2 thirds) or training (1 third of injuries) (Henke, Gläser & Heck, 2000; Henke, Luig & Schulz, 2014; Luig & Henke, 2014; Luig, 2015;). In team-handball the rate of injured women (2000: 21,4%) is higher than men (2000: 13,4%) with most injuries affecting knees (male: 23.0%; female 31.7%) or ankle joints (male: 18.6%; female 22.1%) followed by hands/ wrist (male: 19.8%, female 19.6%) and head (male: 17.4%; female 13.2%) (Luig & Henke, 2014). Younger athletes seem to be more prone to injuries of the upper body regions, especially finger injuries, whereas with advancing age there is an increase in injuries of the lower extremities, in particular knee injuries. Most players get injured in contact situations. Players in offensive actions are at more risk than defence players. Professional athletes show notable higher incidence rates than semiprofessionals or amateurs (Luig, 2015; Luig & Henke, 2014).

The influence of psychological factors on injury incidence is discussed by several researchers (e.g. Brewer, Andersen, & Van Raalte, 2002; Heil, 1993, Ivarson, 2015). Competitive stress seemed to be the core variable to explain injury incidence. A potentially stressful athletic situation (e.g. competition, important practice, poor performance) can contribute to injury depending on the athlete how threatening he or she perceives the situation to be. A situation perceived as threatening increases state anxiety, which causes a variety of changes in focus of attention and muscle tension (Weinberg & Gould, 2015). For understanding injury risk from the psychological perspective two models will be described: (1) the biopsychosocial view of injury (Brewer et al., 2002) and (2) the model of stress and athletic injury (Anderson & Williams, 1988).

(1) The *biopsychosocial view of injury* (Brewer et al., 2002) is developed to explain psychological reactions to sport injuries from different perspectives. Injury characteristics (e.g. severity, type) and socio-demographic characteristics (e.g. age, gender) will influence biological (e.g. immune functioning, circulation), psychological (e.g. affect, behavior) and social/ contextual factors (e.g. social network, life stress). In turn, these three factors will have an indirect effect on sport rehabilitation outcome (e.g. functional performance, readiness to return to sport).

(2) The *model of stress and athletic injury* (Anderson & Williams, 1988) is the most recognized theoretical framework to explain psychological reactions to sport injuries (Ivarson, 2015). Injury risk is influenced by the athlete’s appraisal of a potential stressful situation and the magnitude of stress response. This bidirectional relationship is influenced by four different factors: personality, history of stressors, coping resources, and psychological skill interventions. These factors mediate the stress response and injury-risk.

Personality traits are a main category of psychological risk factors. Traits that increase injury risk are anxiety (Johnson & Ivarsson, 2011), worry (Noh, Morris & Anderson, 2005) and stress susceptibility (Ivarson & Johnson, 2010). On the other hand, athletes with adaptive personal traits like hardiness (Wadey, Evans, Hanton, & Neil, 2012), optimism (Wadey, Evans, Hanton & Neil, 2013) and self-confidence (Kleinert, 2007) seemed to be injured less often than other athletes (Ivarson, 2015). The relationship between personality and the stress response seems to have an indirect effect on injury rates. Additionally, social support serves as a mediator of injury risk. Life stress will create a higher risk for athletes with low coping skills and low levels of social support (Weinberg & Gould, 2015). Further certain life events, daily hassles or experience of previous injuries might increase injury risk (history of stressors). High level of life event stress (positive and negative) increased injury risk among junior soccer players (Rogers & Landers, 2005). The impact of hassles on injury risk has been investigated in only few studies so far (Ivarson, 2015). Previous injury experience might increase injury risk because of insufficient recovery state or lack of psychological preparation. Also, Coping and injury risk is interrelated. Problem-focused strategies are directed towards the demand itself, whereas emotion-focused strategies are related to the emotional reactions (Lazarus & Folkman, 1984). Adaptive strategies can be used to influence the athlete's appraisal of stressful situations and to decrease the magnitude of stress response. Psychological skill interventions can change inefficient stress appraisal routines, muscle tension or the magnitude of stress response (Anderson & Williams, 1988). Those techniques can be cognitive restructuring, confidence training, realistic goal setting as well as relaxation skills, imagery, or distraction desensitization. The intervention program should be applied by a professional sport psychologist. Empirical studies have shown positive results (i.e., fewer injuries in the experimental group compared to the control group; Ivarson, 2015).

This theoretical framework demonstrates the high incidence of personality factors, resources or coping skills on injury risk. Athletes at higher risk can be characterized by combinations of high trait anxiety, high life stress, low psychological and coping skills, low social support, and high avoidance coping. On the other hand, athletes at high risk can profit from stress management training (Weinberg & Gould, 2015). Ivarson (2015) conducted several studies with Swedish soccer players to analyze the impact of stress on injury risk and the effectiveness of intervention strategies. These findings can be transferred to team-handball. Weinberg & Gould (2015) draw several conclusions out of these findings: Identify stress prone athletes. Educate your athletes in stress management techniques and coping skills. Develop a system of social support within your team.

Psychological factors also influence return to sports. Two post-injury perspectives are focused in research: (1) the psychological reactions to injury and (2) psychological factors that facilitate the rehabilitation process and return to sports (Ivarson, 2015; Weinberg & Gould, 2015). The reaction after injury seems to be very individual and does not follow a stereotypical pattern. Some athletes perceive the injury as disastrous, some might perceive it as a relief to get out of strenuous practice or to have an acceptable excuse for quitting (Weinberg & Gould, 2015). Common reactions are sadness, grief, fatigue, depression, and anxiety. Most of these emotions could also be present during the rehabilitation process. Weinberg and Gould (2015) describe some typical responses to injury. Some athletes perceive an *identity loss*. They feel that an important part of themselves is lost. Coaches can help athletes when they provide a supportive environment during the rehabilitation process. The impact of group processes can be twofold. Injured players can profit from group cohesion during rehabilitation. On the other hand the fight for open positions by other players can be a stressor for the injured athlete.

The psychological rehabilitation is part of a complex process of injury recovery. Hermann and Eberspächer (1994) recommend a holistic approach to rehabilitation. Physical therapy should be accompanied by psychological strategies to facilitate recovery from injury and follow a four stage model to explain the psychological rehabilitation process. Mayer and Hermann (2009) imply that in the acute phase small movements and first steps of mental training. Phase one (acute phase) is followed by stage two (transition phase), which is used to find access to the rehabilitation program. Basic movements –(depending on the severity of the injury) are part of the recovery plan. Stage three (phase of athletic rehabilitation) follows the concept of sport-unspecific training units and includes the start of more sport-specific training units. The fourth stage (phase of preparation for competition) is used to monitor the athlete during training routine to become stable for the demands of competition. This phase is often not supported by competent personnel. Many athletes tend to overestimate their physical and mental state during rehabilitation, thus increasing the risk of re-injury.

Weinberg and Gould (2015) use a three stage model to describe the rehabilitation process. In the *injury or illness phase* instant support for the athlete is needed to help coping with the emotions. In the *rehabilitation and recovery phase* it is important to maintain motivation and adherence to the recovery. Working closely with the athlete after setbacks and setting goals for the upcoming recovery period are useful in this phase. The third phase, *return to full activity*, includes physical preparation and gaining mental stability to return to normal function in competition. The authors emphasize psychological support as a tool for the recovery process, which should be facilitated by several psychological interventions and procedures. These include a set of short term goals, educating the athlete about the injury and the recovery process, teaching specific psychological coping skills, preparing the athlete to cope with setbacks, fostering social support and learning (and encouraging the athlete to learn) from other injured athletes. Weinberg and Gould (2015) identify four different psychological strategies (goal setting, self-talk strategies, imagery and relaxation training) that influence the rehabilitation adherence of athletes.

In summarizing the psychological perspective of injury risk and rehabilitation these perspectives should be used to offer a transfer in different competitive sports and also in team handball. The psychological aspects of injury should give an idea for the onset of preventive strategies before an injury and also for strategies in the rehabilitation process after injury. There is a lack of empirical data on how to deal with an injury. Quite often, only the medical aspects and physiotherapy are focused in the rehabilitation process. Psychological strategies should be implemented more often to help the athlete get along with fear, misunderstanding, and helplessness after injury. Psychology offers different strategies to enhance recovery. They educate athletes for a better understanding of the rehabilitation process and help building up resources and self-efficacy to regain the mental stability for competition, thus taking into account the connection between psychological factors and injury.

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ASSESSMENT OF THE SATISFACTION DEGREE OF BEACH HANDBALL PRACTICE IN SPORT SCIENCES STUDENTS

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Abstract
The aim of this work was to know the degree of satisfaction that occurs in athletes practising beach handball. To perform assessment, the mDES instrument was used. 219 questionnaires were passed to sports science students of the University of Alcalá after the beach handball practice. The index of positive sensations obtained an average of 2.7 over 4 and that of negative sensations, an index of 0.47 over 4. Statistically significant differences were found. It can be concluded that beach handball produced a high degree of positive feelings.

Keywords: questionnaire, mDES, sport, pleasure, emotions.

Introduction
Beach handball has very specific characteristics that differentiate it from any other sport in a very marked way (Zapardiel, 2015), so it is interesting to observe how these differences affect their athletes, their way of understanding it and their emotions.

The emotions that take place during a specific competition, before or after this, determine the characteristics of this subject, either at the time of a phenomenon or as indicated, before or after. Therefore, emotions are a factor to take into account in sports performance as it can affect this directly or indirectly.

Rannou, Prioux, Zouhal, Gratas-Delamarche & Delamarche (2001) comment that the work of the different fields of positive psychology and their contributions to the study of positive emotions has increased the spectrum of the emotional phenomenon, giving it great importance and analyzing the different actions and their repercussion in the result of the emotions. However, traditionally, sport psychology has focused exclusively on the study of negative or dysfunctional emotions, such as anxiety (Palumbo, Medrano, Lussenhoff, González, & Curarello, 2011).

The study of positive and negative emotions determines the emotional state, that is why its analysis is very important; focusing attention in this case on the theoretical model of the theory of emotions based on Fredrickson (1998, 2013) and Fredrickson, Tugade, Waugh and Larkin (2003), being adapted to the sports field by Jiménez-Almendros (2017).

The mDES tool and the theory of emotions by Fredrickson has effectively evaluated the general population in various situations, confirming the importance of emotions in the individual's overall analysis and the validity of the tool (Fredrickson et al., 2003). Similarly, for athletes, competition is a trascendental situation in the sporting context, so the study of the emotions that occur must be developed and evaluated (Jiménez-Almendros, 2017). In this case, we focus on a team sport, such as beach handball, a situation where, as it has been shown, emotions influence team performance (Skinner and Brewer, 2004).

The tool used –mDES- (Fredrickson et al., 2003; Fredrickson, 2013). The mDES adaptation, validity and psychometric quality in the sport was analyzed by Jiménez-Almendros (2017), with a coefficient α of 0.86, superior to 0.80, index recommended for general application to athletes (Graupera, 2007).

The differences found in terms of Gender and from it at any level of performance are minimal and not significant. As for the performance level, there are small differences in positive emotions at low or very high levels of performance with high mean values (Jiménez-Almendros, 2017; Graupera et al., 2011). Finally, depending on the type of sport, age and years of experience, there are differences in team sports with respect to individual sports in aspects of positive emotions with higher values in team sports, but in terms of negative emotions the results are similar (Jiménez-Almendros, 2017, Kane, 2009). In addition, in team sports there are studies that show how individual emotions affect the group and are passed on, as well as the control or repression of individual emotions in favour of the group (Tamminen and Crocker, 2013).
Also, significant relationships were found in the age and in the years of experience in sports with negative feelings, resulting in a decrease when the age and experience of the subjects increases (Jiménez-Almendros, 2017, McCarthy, Allen and Jones (2013), Bebetsos, 2015).
On the other hand, Lazarus, Kanner and Folkman (1980) determine the adaptive function of positive emotions, which allow to soften stress situations and facilitate coping in situations when difficulty increases.

For all the above-mentioned information in this introduction, we set out to know the satisfaction degree produced in athletes playing beach handball.

Methods

Participants

The sample of the study was constituted by 216 participants in the XI Sports Week of the University of Alcalá, an event in which students and staff of the university participate, and in which, among others, a beach handball competition takes place. In this tournament, 32 teams participated. The mean age of the participants was 22.8 years with an average of 13 years of sports experience (Table 1).

Table 1. Age and years of experience of the study sample

	Men (n=166)		Women (n=50)		Total (N=216)	
	Mean	SD	Mean	SD	Mean	SD
Age	23,1	5,5	21,7	2,1	22,8	4,9
Years of experience	13,3	4,9	11,7	4,5	13,0	4,9

Within the competition level of the participants, we found a majority in men who competed at a regional level, 44.4%, and a majority in women who competed at a national level, 55.6%. 4.9% of all participants competed at an international level. These statistics show that a large majority of the participants have played sports at competitive levels, mostly in team sports (70.1%) versus individual sports, 29.1% of the total.

Material

The research study was carried out with the mDES questionnaire validated by Jiménez-Almendros (2017), adapted from Fredrickson at al., (2003) and Fredrickson (2013). All questionnaires were digitized in a database. Statistical analysis was performed using SPSS software v.22.

Procedure

The measurements were made during the XI Sports Week of the University of Alcalá, held at the beach sports facilities of the external campus in May 2017. The study project was presented to the organization committee and, once it was approved, informed consent was obtained from all participants. Thereupon, the mDES tool (Jiménez-Almendros, 2017) was applied at the end of each beach handball match. Previously, all participants had received instructions about how to complete the questionnaire. Subsequently, all questionnaires were registered in the database and analyzed statistically.

Statistical analysis

Data were transferred to a database and then processed with the SPSS v.22 software. The normality of the dependent variables was verified by the asymmetry and kurtosis tests, resulting in normal variables. The contrasts of mean differences between gender and sports level were studied by multivariate and univariate analysis of covariance. For this, age and years of experience were taken as covariables. Subsequently, a descriptive and inferential analysis was performed among the study variables. Finally, the correlations of the dependent variables and the rest of the research variables were studied.

Results

Normality test

Normal samples are usually considered when having coefficients of asymmetry and kurtosis between -2 and 2. In Table 2, it can be observed that the coefficients obtained from the dependent variables were within that interval. Therefore, it was concluded that they met the normality criteria.

Table 2. Analysis of the asymmetry and kurtosis of the dependent variables

	Asymmetry		Kurtosis	
	Statistical	SE	Statistical	SE
Positive	-0,811	0,164	0,780	0,327
Negative	1,583	0,164	2,671	0,327

Descriptive analysis of positive and negative feelings depending on Gender, type of sport and competitive level

Table 3 shows measures of central tendency of the positive and negative feelings depending on gender. Table 4 shows measures of central tendency of the positive and negative feelings depending on the type of sport.

Table 3. Descriptive analysis depending on Gender

Gender		Positive	Negative
Man	Mean	2,745	0,487
	N	166	166
	SD	0,688	0,549
Woman	Mean	2,488	,386
	N	50	50
	SD	0,653	0,365
Total	Mean	2,685	0,463
	N	216	216
	SD	0,687	0,513

Table 4. Descriptive analysis depending on sport type

Sport type		Positive	Negative
Individual	Mean	2,484	0,569
	N	67	67
	SD	0,769	0,670
Team	Mean	2,759	0,429
	N	150	150
	SD	0,650	0,434
Total	Mean	2,674	0,472
	N	217	217
	SD	0,699	0,520

Table 5 shows measures of central tendency of the positive and negative feelings depending on the competitive level.

Table 5. Descriptive analysis depending on competitive level

Level		Positive	Negative
Local	Mean	2,650	0,400
	N	22	22
	SD	0,696	0,500
Regional	Mean	2,688	0,500
	N	85	85
	SD	0,703	0,494
National	Mean	2,680	0,467
	N	91	91
	SD	0,684	0,550
International	Mean	2,800	0,311
	N	9	9
	SD	0,694	0,413
Total	Mean	2,686	0,467
	N	207	207
	SD	0,689	0,516

Inferential analysis of positive and negative feelings depending on Gender and competitive level

The covariable age is significant and has a significant association with the dependent variables of positive and negative feelings (η^2=0.006, p<0.001). Also, we can observe that the covariable years of experience showed no significance (p=0.358). The effect of Gender on the variables of positive and negative feelings was significant (p<0.001). However, the competitive level was not significant (p=0.834) and with a degree of association close to 0 (η^2=0.007).

There is only significance in the negative feelings variable depending on Gender and with a mean effect (η^2=0.033, p<0.05). The remaining variables were not significant and therefore did not interfere with the study when the sample was taken as a single group.

Differences depending on Gender

We found significant differences in positive feelings between men and women (p<0,05). Men have greater positive feelings during the dispute of beach handball games. Negative feelings do not show significant differences between men and women (p=0.225).

Differences depending on the competitive level

Table 6 shows measures of central tendency of the positive and negative feelings in relation to the competitive level. No significant differences were found in any of the variables (p<0.05). It can be highlighted that the greatest positive feelings and the smallest negative feelings are found at the international level (Figure 1).

Table 6. Polynomial contrast of feelings depending on competitive level

		N	Mean	SD	Minimun	Maximun
Positive	Local	15	2,650	0,696	1,4	3,9
	Regional	72	2,688	0,703	0,4	4,0
	National	66	2,680	0,684	0,3	3,9
	International	9	2,800	0,694	1,4	3,7
	Total	157	2,686	0,689	0,3	4,0
Negative	Local	15	0,400	0,500	0,0	2,2
	Regional	72	0,500	0,494	0,0	2,3
	National	66	0,467	0,550	0,0	2,7
	International	9	0,311	0,413	0,0	1,1
	Total	157	0,467	0,516	0,0	2,7

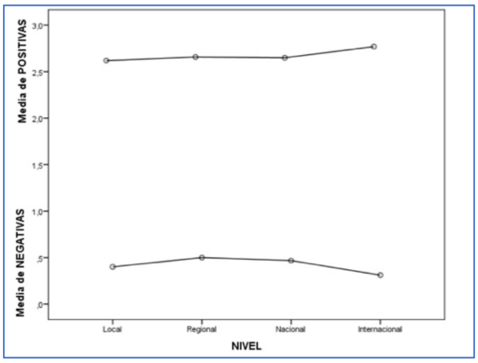

Figure 1. Negative and positive feelings mean depending on competitive level

Differences depending on the result

The results showed significant differences in the variable positive feelings between losing, winning and winning in the shoot out. Losing in the shoot out showed no significant differences. In the negative sensations variable only negative differences between winning and losing were found.

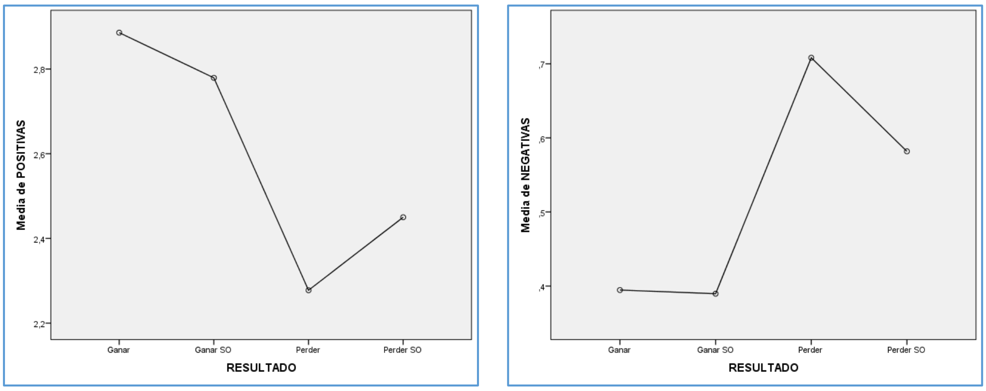

Figure 2. Positive and negative feelings mean depending on result

Discusion

Not many studies have analyzed positive and negative feelings in team sports. For this reason, our study will help increase the number of assessments in this sense and, especially, in beach handball since the only study that has collected data of this sport is the one by Jiménez-Almendros (2017).

In our research, the age variable showed a significant difference and a big association (p <0.001) with the positive and negative feelings dependent variables. These results agree with Jiménez-Almendros (2017) but, in the case of this study, the association was of moderate intensity. Positive feelings increase with age, in the same way negative feelings decrease. This relationship is also found in the studies by Jiménez-Almendros (2017) and Graupera et al. (2011). It was observed that the years of experience showed no significance (p <0.358) in relation to positive and negative feelings in beach handball matches. These results do not agree with those found by Jiménez-Almendros (2017) and Graupera et al. (2011). The non-concordance could be justified due to the fact that the sample was very homogeneous in relation to the years of sports experience.

In the analysis of the positive and negative feelings depending on the different sexes, we found significant differences in the positive feelings between men and women. Men have greater positive feelings during the dispute of the beach handball matches, being a similar tendency to the one found in Crocker and Graham (1995). On the contrary, in Jimenez-Almendros (2017), Dias, Cruz and Fonseca (2014) and Kouli, Bebetsos, Kamperis and Papaioannou (2010), equivalent measures are found for men and women, and that this equivalence is maintained at all levels of sports competition. Therefore, we can observe how the information is contradictory is this sense (Nicholls and Polman, 2007).

In the analysis of the positive and negative feelings depending on the competitive level, we did not find significant differences in any of the variables (p <0.05). It can be highlighted that the greatest positive feelings and the smallest negative feelings are found at the international level. In this sense, the trend is similar to that of Jimenez-Almendros (2017), with negative feelings with very low values and positive feelings with medium-high values, where they find very slight significant differences, something similar to what was found by Graupera et al. (2011).

The results showed significant differences in the positive feelings variable between losing, winning and winning in the shoot out. Losing in the shoot out showed no significant differences compared to losing. In the negative feelings variable only negative differences between winning and losing were found. Our study showed clearly that winning entails greater positive feelings and reduces the negative sensations. These data coincide with those of Palumbo et al. (2011) although in this study victory and tie were valued. In the case of the tied matches, large declines of the positive feelings and large increases of the negative ones were found. In our case, the positive feelings in the losses diminished but the negative ones showed moderate increases. The playful-competitive nature of beach handball could explain this difference. Also, it can be observed in our research that the more exciting the achievement of victory the greater positive feelings involved.

It should be mentioned that for many of the athletes who were part of this research this was the first time they had a competitive experience in this sport. In general, even in the face of defeat, positive feelings were far superior with statistically significant differences. In this sense, not only should the athletes be exposed to experiences that make them regulate their negative feelings states, but interventions should also be designed to provoke an increase in positive feelings if this is to achieve an increase in their psychological well-being (Palumbo et al., 2011).

Conclusions

Positive feelings of women and men are different when they are competing in beach handball in a university competition. However, negative feelings are very similar in the two sexes at this same level.

Men have greater positive feelings than women when competing in beach handball games at a university event.

The competitive level and the years of experience do not make any difference as to negative and positive feelings after playing beach handball matches in a university championship.

Winning produces greater positive feelings and less negative feelings when university athletes compete in beach handball. The greater emotion involved in achieving the victory, the greater the positive feelings the athlete will have.

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WHY DO GIRLS START TO PRACTICE HANDBALL AND WHAT IS THE COACH'S ROLE IN THEIR MOTIVATION ENHANCEMENT?

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Abstract
Many authors and their theories explain the process of and motifs for the selection of a particular sport; some emphasize the need for achievement, others accentuate the role of competency or the need to maintain self-esteem. There are three main goals of sports achievement: competitiveness, sporting skills and social approval. The most important factors in athletes' motivation enhancement are the ratio between internal and external motivation and planning of the sports activity goals. The aim of this research was to construct a questionnaire that will collect the following information: Why do girls begin to do handball?, How much the environment affects their involvement in handball?, Is extrinsic motivation important for young handball players?, What is the impact of criticism on young handball players?, What coach's character traits do young handball players prefer?, and What is the coach's role in sport development of young handball players?. The study was conducted with 93 female handball players (15-16 years) from seven clubs participating in the national Croatian Cadet Handball Championship. The questionnaire consisted of 88 items to which the participants could respond on a five-point Likert scale (5 – correct, 4 – partially correct, 3 – not sure, 2 – partially inaccurate, and 1 – completely inaccurate). The greatest differences were obtained in the variables that relate to the reasons for handball training, to the influence of coaches on handball performance and to praise or criticism after a good or bad match. It has been established that girls are beginning to train handball for personal satisfaction and desire for progress, and that they are most motivated to work and progress if the coach praises them. They believe that the coach's most important duty is to teach them something new and correct their mistakes and to be critical during that process, but they do not approve his/her bias, subjectivity, favouritism, or lack of authority in games and training sessions.

Keywords: youth, female, handball players, motivation, coach's role,

Introduction
Numerous authors have devised various theories to explain processes and motifs in the background of selecting a particular sport. Some emphasise importance of achievement motive or need, others single out the role of competency or the need for self-respect maintenance. Participation in any sport is commonly induced by the original interest for the activity *per se* – children want to play, have fun, experience thrill and excitement (Horga, 1993, p. 284). Three fundamental achievement goals in sports are the following: competitiveness, sports skills, and social approval. The two most important motivation enhancing factors are: intrinsic and extrinsic motivation proportions and planning of sports activity targets. Vallerand, Deci and Ryan (1987) consider that focusing on victory, as opposed to focusing on task performance, is primarily extrinsic. They also contend that, in certain cases, a defeat may assume an informational form and via feedback promote athletes' motivation to persist, even to invest additional effort, in sport practice. In that case, they consider, we are talking about interiorised motivation control, not about intrinsic motivation. The coach has a very important role in the formation of his/her athletes' entire personality. Czerwinski (1999) established a very high influence of the coach on female handball players before, during and after a training session. If the coach observes basic principles, like freedom of speech, attention of others while someone is speaking, freedom to express emotions without condemnation, attentive listening, no one should be forced to speak, then he/she may expect successful social interaction with his/her players (Nakamura, 1996). Mocsai (2002) defines positive attributes of the coach and emphasises his/her communication skills – his/her communication should be clear and comprehensible, speech

should be delivered appropriately loud, his/her speaking skills should be cultivated, but also open and individually trimmed. The following positive coach's characteristic is his/her professional training or education that must make him/her capable of organising interesting and versatile training sessions. In social interactions coaches should be righteous, responsible, unbiased, balanced with positive thinking, etc. The last but not the least important coach's feature is his/her ability to establish quality coach-athlete relationship; it embraces: acknowledging players' opinions, team work, positive climate during training sessions, climate that is motivating, open and not overwhelmed by a too high physical, mental and emotional stress. Mocsai (2002) defines also the negative items on the spectrum of coach' features. The first among them is athletes' perception of the coach as a frightening person. Then come other negative features of the coach, like poorly organised training session, with no dynamics, monotonous work during sessions, lack of expert knowledge, favouritism, etc. The coach should avoid the following in social interaction: expressing impatience, restlessness, nervousness, irresponsibility, being late, delay, unequal relationship to players, lifeless behaviour, not seeing or not accepting his/her own mistakes, contemptuous attitude towards players and their abilities, negative, even pessimistic attitude.
The aim of this pilot study was to construct a questionnaire by means of which information on the following questions could be collected: Why do girls start to practice handball?, What impact their environment has on their involvement in handball?, Is extrinsic motivation and to which extent important to young players?, What is the effect of criticism on young athletes' motivation?, Which coach's personality traits are preferred by young players?, What is coach's role in sports development and specialisation of female cadet handball players?

Methods

Participants

This pilot study embraced 93 women handball players (born in 1985 or younger, U16) from seven different clubs), participants of the 2001 national Croatian Cadet Championship in Solin.

Measures

Motivation of the young female handball players was assessed by means of a questionnaire specially constructed for the pilot study. It contained 88 variables (21 groups of complex questions and 20 simple ones). To each of the 88 questions, the players might choose among the five offered answers: 5 – correct, 4 – partially correct, 3 – not sure, 2 – partially inaccurate, and 1 – completely inaccurate. All the participants were divided into seven groups according to their affiliation to the club.

Groups of questions covered the following content topics:
1. Why do girls begin to train and play handball?
2. What are the reasons in the background of their involvement in handball?
3. How do they feel after the match has been lost?
4. How do girls react to praise and what does it mean to them?
5. How do girls react to criticism coming from the coach?
6. Why do they regularly attend practice sessions?
7. What reasons they may have for their practice absentism?
8. What should the coach look like? What characteristics should he/she have?
9. Do players feel stage fright?
10. What is most important for them, i.e., what is their aim in handball?
11. Would they and for what reason stop practicing and playing handball?
12. What is their relationship with the coach?
13. What is their relationship with the parents?

The players filled in the questionnaire during the championship, each club in its separate room, under the researcher's supervision after the detailed instructions had been given.

Statistical analysis
Data were processed so that frequency tables of answers were created together with the contribution percentages of each scale category. Independent samples χ^2-test was used to establish differences among players pertaining to various handball clubs in their answers to particular items.

Results and discussion

Younger cadets' answers revealed that most players chose to involve in handball because they sought for personal satisfaction and wanted to improve themselves (55%), and they practiced it because they wanted to become the best handball players in Croatia (26%). After a good move or goal scored, the most valuable praise is the one coming from the coach (41%), whereas teammates' praises are on the second place (23%). For 74% of younger cadets, coach's praises have enormous influence on their motivation. If there is no praise after a well-played game, most younger cadets (35%) think the only important is their satisfaction with the game performance; simultaneously they do not think they are underappreciated in the club nor they expect any praise next time. Most girls (55%) consider the coach is critical to their performance because he/she wants them to be better handballers and not because he/she wants to humiliate them in front of the others, or to expel them from the team. Girls trust their coach (43%); they are most affected by his/her critic (30%), whereas criticism coming from their parents, environment or teammates have far smaller effect. Younger cadets consider that the coach's primary role is to teach them something new and to correct their errors (58%) and that he/she should assume appropriately critical approach (98%) in that process. All the investigated younger cadets (100%) consider that the coach's bias is unacceptable and that, during training sessions or games, they should not do whatever they wish to do or to behave voluntarily. Also, handballers consider that when things are not going well in a game, nobody and nothing can help them. Even 60% of young handballers agree that the coach is the most important person for their mastery and progress in career. Our players (58%) feel more motivated for work after the coach's public praise; other answers appeared not to have any significant effect on motivation enhancement.

In Table 1 questionnaire items are presented in which statistically significant ($p<0.00$) differences were obtained between the answers of players pertaining to various clubs.

Table 1. Results of χ^2-test applied to 10 different variables

Item	χ^2 (df=92)
1 SREĆA 1 "I feel happier when I get an excellent grade in any school subject than when I perform outstandingly in a match and everybody praise me"	8563.73
2 RAZLPR_1 "Reasons for handball practice cessation: "I do not progress any longer"	8552.74
3 NAJPOH_2 "Praise from my coach is more important to me than teammate's praise"	8594.66
4 BEZPOH_2 „When I perform outstandingly in a match but nobody praises or congratulate me, I feel: Never mind, it is important that I am satisfied.	8707.79
5 TRENER_1 „It is my consideration that every coach should be: honest and fair"	8526.99
6 NEPOVTR I do not trust my coach	8529.66
7 MOTIVTR My coach manages to motivate us before every match	8531.15
8 NENAPVJ_2 (When you are not able to perform a task during practice, then you will: out of pure spite, you will give your best and do the best you can)	8593.01
9 VOLIMRUK (I like to train and play handball more than anything in the world)	8464.961
10 RAZTRE_2 (I do train handball because: If I was not doing handball, I would do any other sport)	8643.90

Statistically significant differences were obtained between the answers of players pertaining to various clubs in the following variables: 1) "I feel happier when I get an excellent grade in any school subject than when I perform outstandingly in a match and everybody praise me", 2) "Reasons for handball practice cessation: "I do not progress any longer", 3) "Praise from my coach is more important to me than teammate's praise", 4) „When I perform outstandingly in a match but nobody praises or congratulate me, I feel: Never mind, it is important that I am satisfied., 5) „It is my consideration that every coach should be: honest and fair", 6) "I do not trust my coach", 7) "My coach manages to motivate us before every match”, 8) „ When you are not able to perform a task during practice, then you will: out of pure spite, you will give your best and do the best you can“, 9) “I like to train and play handball more than anything in the world“, 10) “I do train handball because: If I was not doing handball, I would do any other sport“.

Conclusion

Our girls in general begin to train handball because they want to find personal satisfaction and to have opportunity for improvement and progress and not on their parents’ urge or because they were bored; therefore, their wished goal to become the best handballers in Croatia does not come as a surprise. They are mostly motivated for work, progress and improvement when they receive a praise from the coach. Also, they consider that the coach is responsible for indicating and correcting their errors, therefore he/she may be critical. Our younger cadets experience the coach’s criticism very hard, but they do not consider it as humiliation, insult or exclusion from the team; on the contrary, they understand coach’s critical remarks as necessary in the process of learning and mastery – they know their coach wants them to be the best. The fundamental role of coach is his/her duty to teach them something new and to correct their mistakes in the process of which the coach must assume objective, critical approach with a tone of authority and free of any bias.

This study has corroborated the notion that the coach is an important person with an enormous impact on the young athletes’ lives. He/she is primarily responsible for training process planning and programming, but he/she is also a teacher who nurtures young people and leads them on their way to responsible adults; the coach’s treatment of his/her athletes may either support and promote their development, or may set it back. Coach’s job is not exclusively related to task demonstration and error corrections in sports hall; his/her duty embraces coach’s attitudes and individual approach to each and every young player by which he/she facilitates player’s process of maturation and journey to adulthood. A person engaged in the job of coaching must constantly, year after year, work on him-/herself and improve his/her knowledge of professional and specialisation field, but also of fields of pedagogy and psychology. Every player is a person *per se* who responds individually and typically to the training stimuli (kinesiological, educational, or psychological) during a session; therefore, the coach must approach to each player in a specific way.

Future research on possible factors influencing the selection of a particular sport, athletes’ persistence and the coach’s role in it should be done by means of the well-established questionnaires. Namely, only in that case comparisons will be possible between probable differential factors relevant to the selection of a sport in the population of young handball players as well as the determination of the role the coach may have in their sports development.

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HANDBALL PLAYERS' TRANSFERS IN SLOVENIA FROM 2010 TO 2017 – CERTAIN CHARACTERISTICS

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Summary
The aim of the study was to present certain characteristics of the transfers of handball players in Slovenia from January 2010 to February 2017. Out of 666 transfers, 375 (56.3%) players left and 291 (43.6%) came to Slovenia; 68.3 % of them were men and 31.7% were women. The data were obtained from the EHF database. Among the players (375), who left Slovenian handball (30 nationalities), 57.1% (241) were Slovenes, the others (161) were foreigners. Out of 291 players who transferred to Slovenia (23 nationalities), 101 were Slovenes (34.7%) returning from abroad and the rest (190; 65.3%) were foreigners. In this period the players transferred once (76.2%) to seven times. The transferred players were of 39 nationalities. Since the dynamics of transfers is becoming more and more intensive, Slovenian handball would need a more systematic approach to transfer policy.

Keywords: handball, transfers, quantitative analysis

Introduction
Sport is in the middle of social changes. Transfers and migrations are important part of society nowadays all over the world. According to the study from 2012 (KEA – CDES) on the economic and legal aspects of transfers in team sports, under the European law, transfers must respect the following principles: i) They must be applied in a non-discriminatory manner; ii) They must be justified by overriding reasons in the public interest; iii) They must be suitable for securing the attainment of the objective they pursue; iv) They must not go beyond what is necessary for that purpose.
A large number of commercial interests have a stake in sporting activities: tourism, advertising, the media industry (TV, Internet, telecommunications, publishing), sportswear, fashion, betting, beverage and catering industries, tourism etc. Players' transfers, as a part of sports migrations (labour migrations), have an important influence on sports disciplines development and prospects. Athletes and sports professionals represent a particular social group, which is characterized by a specific lifestyle and a high degree of mobility.
Sports migration has also become a living phenomenon of globalization as well as a form of employment. It has also attracted attention of researchers in sport (Carter, 2007; Darby, 2007; Agergaard, 2008; Maguire and Stead, 1998; Poli and Besson, 2011; Bon et all, 2016).
In general, the objectives of the studies concerning the transfers in sport are: to understand the transfer market and its governance; to map private and public rules governing transfers; to analyse the compatibility of transfer rules and practices with the national and EU laws, and the functioning of those rules.
According to Maguire (2013), sports migration is portrayed as something to celebrate, reflecting an individual's right to move. However, sports migration is bound up in a sports-industrial complex that is itself embedded in a series of power struggles that characterize the global sports system.
In the future, it is also necessary to assess the efficiency of transfer rules in relation to their main objectives: ensuring a competitive balance (through contractual stability, registration periods, solidarity mechanism and transparency rules), protecting minors and ensuring youth development.
Based on intensive globalization and migrations trends, sports have become a commodity, which is a consequence of international investments. Maguire (1996) developed a typology of sports migrants, which consists of five types of athlete-migrants: pioneers, settlers, mercenaries, returnees and nomadic cosmopolitans. After the introduction of the Bosman ruling, this typology was expanded in research by Magee and Sugden (2002) who established 7 categories based on

interviews with football players: mercenaries (their transfer was motivated by money), settlers (they remained in the country for 4–5 years, often also after their sports career had finished), ambitionists (interested in their personal sports career), nomadic cosmopolitans (interested in experiencing another culture), the exiled (those who left a country due to personal or political reasons), celebrity superstars (interested in media attention; e.g. Beckham, Karabatić or Gorbitz in handball).

Migration models in sports, which are not unified and differ depending on the sports discipline, are changing faster every year, also in handball. According to the research of Doupona Topič and Bon (2008), the number of international transfers in men's and women's handball doubled in only three years (1999-2002) and in the next two years it further increased by more than 10%. The number of transfers thus increased from 3.579 in 1999 to 8.597 in 2004. In the next decade this dynamic became even more intensive. In general, there is a large migration tendency in handball from Eastern and Southern Europe to Central and Northern Europe, where the organizational quality is at a higher level. The migration in Danish female handball has always been an interesting example as well. Around two decades ago Denmark and Norway were "El Dorado" for the best European players. There were some Danish clubs with 4 to 10 top level foreign players. With special regulations, Denmark then limited the possibilities for foreigners, and systematically supported the development of domestic players. In the last few years, the best Scandinavian players have been playing in the best European clubs in men's and women's categories. Furthermore, many Scandinavian coaches are sports or labour migrants as well.

Although have not been much reaserc on sport migration in Slovenia, there are quite a few studies on migration in handball (e.g Bon at all, 2016, Doupona Topič, Bon, 2008; Bon at all 2016b) Doupona Topič, Bon, 2008, Gobec et all, 2016). Looking at the current situation in the men's national team and Slovenian national league, it is obvious that the migration situation in Slovenian handball is quite different nowadays. Nearly all members of the men's national team are playing abroad, not only the most experienced ones (Zorman, Kavtičnik, Škof), but also many young, talented players (Janc, Marguč, Zarabec).

It is necessary to point out that many transfers in sport can on the one hand bring many benefits to a sport discipline and some individuals, but can on the other hand hinder the development of domestic talents in sport. While the benefits (mostly economic ones) for players are more or less obvious, the handball federations are faced with a problem of how to organise young talent development in the future. It seems impossible to keep handball competition at an appropriate level with so many of the best players missing. This is certainly a question of career planning in handball as well. In the end, with so many outgoing players, it is logical to ask the question: Can Slovenian handball maintain its position and keep developing while losing so many top level and talented players?

Methods

In this study, we analysed some characteristics of the transfers of handball players in Slovenian handball from January 2016 and February 2017. The data were obtained from the Handball federation of Slovenia (RZS) and the EHF, which supervises responsibility for all transfers of contracted players within Europe in accordance with the IHF Player Eligibility Code and the IHF Regulations for Transfer between Federations. The data include the transfer details ('country from' and 'country to', releasing club, receiving club, EHF release) and some socio-demographic characteristics (nationality, age and gender). We included an illustrative case study (to show the existing situation with some transfer models). For the purpose of the study, SPSS 10.1 for Windows was used.

Results and discussion

In total, 666 transfers were included, 375 (56.3%) players left Slovenian handball and 291 (43.7%) came to play in Slovenia (Figure 1). 68.3% of the players who transferred were men and nearly one third (31.7%) were women. Among the released players (375), most of them (214; 57.1%) were of Slovenian nationality, the others (161) were foreigners. Out of 291 received players, 101 were

Slovenes (34.7%) returning from abroad, and the rest (190; 65.3%) were foreigners. The players who were released from the Slovenian clubs were of 30 different nationalities and the players who came to Slovenia were of 23 different nationalities Transfers of Slovenian handball include 39 different nationalities al together., 18 on both ways (released and received) Players of 18 nationalities were transferring from Slovenia in this period: AUT, BEL, BLR, CRO, DEN, ESP, FRA, GBR, HUN, ITA, MKD, POL, ROU, RUS, SRB, SLO, SUI, SWE) and there are 8 nationalities which players are only at the received part (BIH, BRA, BUL, CZE, EST, GER, LTU, MAR). (Figure 2).

OUT	released	received	IN
1	**MKD**	**MKD**	1
2	**SWE**	**SWE**	2
3	**POL**	**POL**	3
4	**ROU**	**ROU**	4
5	**RUS**	**RUS**	5
6	**SLO**	**SLO**	6
7	**SRB**	**SRB**	7
8	**SUI**	**SUI**	8
9	**BLR**	**BLR**	9
10	**CRO**	**CRO**	10
11	**DEN**	**DEN**	11
12	**AUT**	**AUT**	12
13	**FRA**	**FRA**	13
14	**HUN**	**HUN**	14
15	**ITA**	**ITA**	15
16	GBR	LTU	16
17	BEL	*MAR*	17
18	ESP	GER	18
19	IRI	EST	19
20	ISL	CZE	20
21	ISR	*BRA*	21
22	KUW	BUL	22
23	LUX	BIH	23
24	NOR		
25	POR		
26	QAT		
27	SVK		
28	TUR		
29	UAE		
30	UAE		

Figure 1. The presentation of the transfering players' nationalities. Out of 39 nationalities which are included in transfers in this period, the released players were of 30 different nationalities and the received players of 23.. With yellow colour are market in nationalities, which are only at the released part, and in second column (received) in blue colour, nationalities, which are included only at received part.

Among the released players (375), most of them (214; 57.1%) were Slovenes, the others (161) were foreigners who played in Slovenia for several years (2.5 years on average) and then left the country. Most of them came from one of the former Yugoslav republics; nearly half of all the transfers belonged to neighbouring country Croatia. Out of 291 received players, 101 were Slovenes (34.7%)

returning from abroad and the rest (190; 65.3%) were foreigners. They were of 23 different nationalities, but most of them came from Croatia, Serbia, and Bosnia and Herzegovina. Most (66) top level handball players from the first Slovenian division club were released in 2013.
In the analysed period, the majority of transfers belonged to the Slovenian members of the Champions League: the Handball Club Celje Pivovarna Laško and Velenje in the men's category and the Handball Club Krim Mercator in the women's.

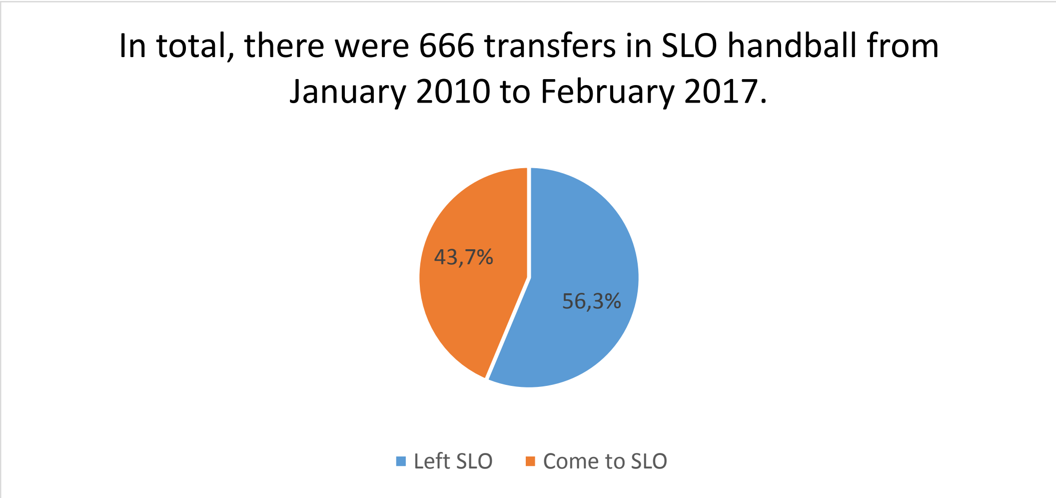

Figure 2. Number of transfers in Slovenia from January 2010 to February 2017

All these data are necessary to be analysed in the frame of the basic data of Slovenian handball. In Slovenia (population: 2 million), there have been 6000 registered players in different competition systems. In addition, the SLO handball federation organizes competitions also in mini handball as tournaments and sports festivals (2000 - 4000 children attend these competitions each year). Out of 6000 registered players, the number of women's players differs from 1400 to 1700 each season. In the season 2016/2017, out of 88 clubs at the senior level, there were 37 men's clubs (26 in the first division and 11 in the second) (http://www.rokometna-zveza.si/).

Since becoming independent in June 1991, Slovenia registered the first big increase in handball transfers after the season 2002/03, when HC Prule, one the most successful clubs at that time went bankrupt. Nearly all players from Prule went abroad. The second big increase was after 2004, when Slovenia won silver medal. The team's success was followed by a great interest in some Slovenian players. In that period, it was of big importance that in 2004 the leading club Celje Pivovarna Laško changed its basic sports strategy from "buying" foreign top level players to the strategy of developing domestic young players from the grassroots to the top. At the end of 2016, there were less than 20 foreign players in the Slovenian first division (www.rokometna-zveza.si), while in 1993, 2 years after Slovenia had gained independence, there were more than 30. After 1991, Slovenia introduced a limit for foreign players: only 5 foreign players were allowed to play in one Slovenian club at the same time. The most intensive "trading" occurred with the neighbouring countries (Figure 3), although Slovenian players transferred even to the United Arab Emirates and Qatar.

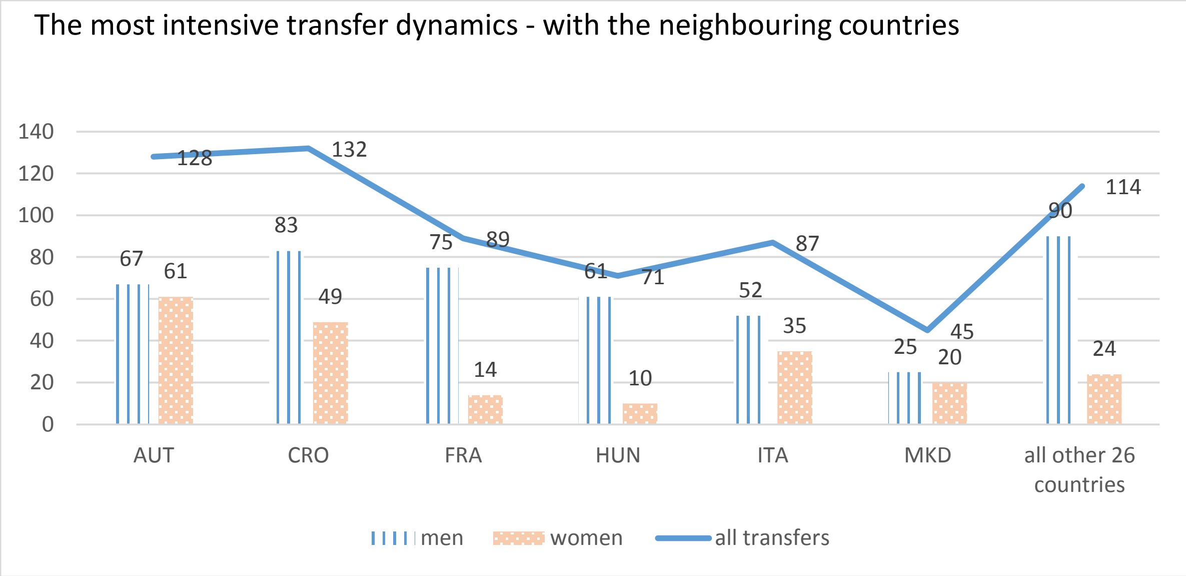

Figure 3. The most intensive transfer dynamics - with the neighbouring countries and France

An example from the database:

from _ to	Country	CLUB
0000–2006	SLO	Celje Pivovarna Lasko
2006–2009	SPA	Spanien BM Valladolid
2009–2011	SPA	Naturhouse La Rioja
2011–2012	GER	TV Bittenfeld
2012–2013	QAT	Katar Quiyada
2013–2014	HUN	ETO-SZESE Győr FKC
2014–2017	SPA	Helvetia Anaitasuna
2017–	GER	ASV Hamm-Westfalen

Figure 4. One of the Slovenian player with 7 transfers to 5 different countries and two continents

Men's handball and the national team

In Slovenian handball, most of the players in the senior team have been playing abroad. This is especially true for the 14 members of the first squad. Most of them have been playing in Hungary, Poland, Croatia and France, which all belong to the strongest and best-organized handball leagues in Europe. This situation was evident at the World Championship in France, 2017: out of 16 members of the national team, 9 players had been playing abroad in top European clubs (SC Magdeburg, MBK Veszprem, PPD Zagreb, FC Barcelona, MOL Pick Szeged, Montpellier Agglomération Handbal, lTHW Kiel). At the Olympic games in Rio, 10 out of 17 players had been playing abroad. In the qualifications for the European Championship 2016, 15 out of 18 players were members of foreigners clubs. Slovenia has also some cases with many transfers (Figure 4), not only in Europe.

Case study

We used illustrative case study to show the existing situation in with 4 different transfer models (2 for men's' and 2 for women's handball).

1. Stability- less is more: Vid Kavtičnik

He is a player with 181 matches in the national team (scored 510 times). He played at the Olympic games in Athens in 2004, and at the age of 32 in Rio 2017. He started his career in Slovenia, in Velenje. An important step for his career was his participation in the European Championship 2004 in Slovenia, where Slovenia won silver medal and he won the best right back award.. His first transfer came was in the season after Euro 2004, to Germany, Kiel, for four years. Since 2009 he has been playing in France (Montpelier). He is living in France with his family (wife and two children). https://www.sports-reference.com/olympics/athletes/

Years	Team
1995–2005 2005–2009 2009–	SLO RK Gorenje Velenje GER THW Kiel FRA Montpellier HB

Figure 5. Vid Kavtičnik

2. Top level: many options/ optimal choices: Uroš Zorman

He is one of the most remarkable players from Slovenia and at the top of the national team statistics. He was captain of the national team at the Olympics (Athenes - 2004 and Rio - 2016). He played 225 matches and scored 523 goals for Slovenia. He started as a really young player in a new founded handball club Prule in 1990 and since then he has been playing in the EHF Champions League for more than 20 years in three different countries (SLO, ESP, POL) and 5 different clubs. He developed as a player in Slovan, then he played for 4 years in Prule, then Celje Pivovarna Laško. After that he played in Spain, first for C.BM. Ademar Leon (one season) and then in BM Ciudad Real (3 seasons). Since 2011 he has been playing in Poland (Vive Targi Kielce). He has scored 397 goals in the Champions League altogether. He is living in Poland with his family (wife and three children). In 2016, he finished his national team career. (https://www.sports-reference.com/olympics/athletes/)

Years	Team
–2003 2003–2004 2004–2006 2006–2009 2009–2011 2011–	SLO RD Prule 67 SPA CB Ademar León SLO RK Celje SPA BM Ciudad Real SLO RK Celje POL Vive Targi Kielce

Figure 6. Uroš Zorman

Women's handball and the national team

The situation in the women's national team nowadays is quite different from men's. Currently, 4 (out of 18) players in the senior national team are playing abroad (in France, Switzerland, Germany and Romania). Three years ago, the situation was similar to the men's team – 9 players were playing abroad (3 in France, 4 in Germany, 1 in Macedonia, and 1 in Romania).

Out of all women's players who has transferred abroad most of them (83.2%) transferred only once. Nearly half of them (45.2%) already returned; the are still playing abroad.

3. Optimal career planning: from participation to the top: Ana Gros

Ana Gros (26) is playing her 7th season abroad. She started in Slovenia, in Velenje, moved to Olimpija, then to Krim, and at the age of 19 moved abroad (first to Hungary, then to Germany and in 2014 she transferred to France (Metz). She scored 33 times in 6 matches. She was French Championship top scorer in 2016 and twice (2015 and 2016) top right back in the same league.
She played 66 games for the SLO national team and scored 274 times.

Years	Team
–2009 2009–2010 2010–2012 2012–2013 2014–	SLO RK Olimpija SLO RK Krim HUN Győri Audi ETO KC GER Thüringer HC FRA Metz Handball

Figure 7. Ana Gros

4. Duel career/transfer case: Neli Irman

She has been playing for many years (21) at the top level, in different European leagues. She started in the handball club Žalec. From there she went first to Krim (the Champions League), then to Olimpija and the fourth step was RK Zagorje (the club ranked second in Slovenia). Then she made the next step in her career – she decided to join HC Lokomotiva (CRO), which playedChampions League. After a financial breakdown, she first came back to Slovenia and then went on to Montenegro. In the season 2015/2016 she scored 16 goals for Budučnost (MNE), 1.8 goals per match. In the season 2016/17 she scored 38 times (2.2 on average in 16 matches). In the last season, she moved to Switzerland, with half-professional status, combining her sports career and new working experience.

Years	Team
–2000 2005–2008 2010–2010 2012–2013 2013–2014 2014–2015 2014–2015 2015–2016 2017–	SLO RK Žalec SLO RK Krim Slo RK Olimpija SLO Zagorje SLO Krim CRO Lokomotiva SLO Zagorje MNE Budučnost SWI Spono E.

Figure 8. Neli Irman

Neli Irman scored 215 times in 85 matches for the national team of Slovenia.
The present study is part of several studies about transfers, migration and career planning in handball in Slovenia from different points of view (Bon at all 2011; Doupona, Bon, 2008; Bon, Doupona Topić and Sibila, 2016; Gobec, Zupančič, Bon, 2016).
If these transfer dynamics continue, will the players from the junior and even youth teams go and play abroad as well? Actually, it is obvious that the intensity of transfers has become a reality in modern sport all around the world. Some questions about transfer regulation are still open. Do

transfer rules contribute to balanced and fair competition safeguarding uncertainty in handball results? One of the main questions is also if the regulation sufficiently encourages the development of young talents; are transfer's fees fear enough? Handball needs transfer regulations that contribute to the economic development of the sport.

Conclusion

Transfers are important part of the handball development in Slovenia. The dynamics of transfers becoming more and more intensive including more clubs and countries. What will the above mentioned transfer dynamics and policies mean for Slovenian handball in the future? It seems that there are several possibilities. Maybe the Slovenian case can even be a model for similar small countries. In general, good results of Slovenian handball national teams offers good transfer possibility for the players. Playing in the biggest European clubs is still a "dream job" for young Slovenian players. On other hand, some facts, including the data of the present study, could lead handball authorities to think how to re-organize to further development even better environment in Slovenian handball (good national leagues, better management in clubs, higher media coverage, appropriate financial possibilities,...) and to slowly reduce the number of transfers out of Slovenian handball. Maybe our data and those analysis can provide the basis for a new strategy in transfer policies, regulations.

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THE COMPARISON OF 4v4 AND 5v5 GAMES FORMS IN OFFENSIVE GAME EXPRESSION OF HANDBALL AT SCHOOL

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Summary
The purpose of this study was to analyse the 4v4 and 5v5 games forms on the Handball game quality and attack competence in Physical Education classes. Sixteen students from 6th grade (11-12 years old) were involved, in the scholar year 2017-18. The results were inconclusive. However from a pedagogical perspective the 4v4 is considered being more appropriate to introduce Handball to beginners.

Keywords: handball, basic game form, teaching, game performance

Introduction
In the last few decades several models centered in the game logic and tactical reasoning have been developed, such as Teaching Games for Understanding (Bunker & Thorpe, 1982), Play practice (Launder, 2001) or Tactical Games Approach (Mitchell, Griffin, & Oslin, 2006). These approaches have underlined the need for an ecological learning process and development of playing competence, and suggest the use of modified or reduced game forms to promote the authenticity of play practice and to shape game complexity to the learners' level.
Therefore, in the early stages of learning, children might be introduced to handball through the full game (7v7), or through modified game forms (*e.g.,* 4v4, 5v5 or 6v6). The most appropriate game form to work with absolute beginners, either in a club or in a school, is a usual subject of debate among practitioners. In Portugal, the game 5v5 (Mini-Handball), with individual marking, is widely implemented in formal competitions for children, mainly under 9 years of age, but there are regions where the full game (7v7) is still dominating. Other countries (*e.g.,* Denmark) adopted an intermediate game form (6v6), which renders a more flowing transition to game 7v7.
In the Portuguese Physical Education Curriculum, the mini-handball game is introduced in the 7th grade (12-13 years). It is also possible to introduce this sport in 6th grade, but there is a lack of guidelines about how to do it. In the following years the full game is introduced without clear recommendations about defensive procedures to be adopted.
The approach proposed by Estriga and Moreira (2014) uses a spiral-learning model, structured in progressive learning stages, with increasingly game play complexity and technical-motor demands. Therefore, a sequence of game forms are proposed, such as 4v4, 5v5 and 6v6, with distinct defensive principles linked with the playing solutions intended to be learned.
When starting to teach handball with beginners we often realize that we should be aware of beginners' level of play and readiness to meet a certain level of play complexity. Therefore, the purpose of this study was to analyze the expression of different game forms, namely the 4v4 and 5v5, in a reduced court size, on beginners game-play quality, individual playing competence and player involvement in attack phase. It is our aim to produce knowledge about the most appropriate practices in the empowerment of learning, involvement and integration of the students in the first stages of Handball learning at school.

Methods
Context
This experience occurred during the Practicum (Master degree in Physical Education in Faculty of Sport, University of Porto), in a School located in the metropolitan area of Porto.

Participants

Sixteen students from the 6th grade (10 female and 6 male; 11-12 years old), without previous experience in handball, were evaluated in the first day of the handball unit plan. Therefore, during the diagnosis assessment the students performed two matches, where the two game forms were used. The Ethical canons (written informed consent with assurance of anonymity, and confidentiality of personal data) were obtained from all child and their parents.

Description

Two matches of 10 minutes each were performed, with 10 minutes of rest. Taking into account the available space for the class, a small sized court (17mx10m) with a straight goal area line (4m distant from goal) was used. The first game form used was randomly selected, so in this case the 4v4 was first played. Some formal rules were shaped according to the learners' level of play and pedagogical aims, for instance the physical contact was forbidden and throw-off was replaced by the goalkeeper throw.

The students were divided into two heterogeneous and balanced teams (8 players each) by the pre-service teacher in charge of the class.

The matches were videotaped to provide a more accurate and detailed assessment of the game play. We used a HD video camera positioned diagonally to the field to capture the entire space and to minimize game-play occlusion.

Data Collection and Analysis

The data were extracted for the diagnosis evaluation performed in first lesson of a short unit plan (a set of 5 lessons).

To analyze the individual and collective behaviour in attack, we used two different tools:

i) A notational analysis to characterize the offensive sequences, adapted by Almeida, Ferreira, and Volossovitch (2012). This instrument focused on collective behaviours in attack defined according to the criteria of beginning and ending of a ball possession. For this propose we adapted the following simple indicators, that are simple counts of game performance: *duration of ball possession*; *number of players involved in attack*; *number of actions with ball*, *number of passes* and *number of shots*. In addition we developed other indicators to analyze the:

a. Attacking actions that led to play advantage (space, positional or numerical) (ball possession lost without setting up a scoring opportunity; break away/surpasses the opponent; beats the opponent with the ball; "give and go" with a returning pass; receives ball with wide positing; dribble-progressing; immediate fast attacking after ball interception; scoring attempt without offensive advantage.

b. Final result of the offensive sequence (goal or 7m throw; miss shot; lost the ball; and defensive interception).

c. Opposition level in score attempt (throw without opposition; throw with opposition; long-distance throw).

d. Zone shoot were the finishing took place (Figure 1).

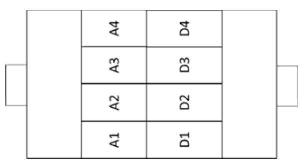


Figure 1: Division the handball pitch into 9 zones of action, 4 in each midfield plus goalkeeper area

ii) A tactical evaluation tool to analyze the individual offensive technical-tactical behaviours. We used the Handball Tactical Performance Evaluation (HTPE) (Ferreira, Estriga, & Graça, n.d.), adapted from the Game Performance Assessment Instrument (Oslin, Mitchell, and Griffin, 1998) and from the instrument developed by Tallir, Lenoir, Valcke, and Musch (2007). The actions were record and classified according to the game phase, the court zone of action, type of decision-making, the motor execution and its effectiveness (action outcome). The individual performance of the last three observed categories was classified as *appropriate/efficient* or *inappropriate/inefficient*, according to the established criterion of response. The behaviours and adequacy data were re-coded in the following index's: i) decision making with ball; ii) decision making without ball; iii) skill execution; iv) effectiveness and v) game involvement. The various indexes were computed based on the number of appropriate actions per the number of actions performed (Oslin et al., 1998). In order to ensure that everyone had the same evaluation time we only assessed 5 minutes of play per each player.

The data were recorded on a spreadsheet and exported to the SPSS Statistics (version 24.0). The level of significance was 5%.

Results and discussion

The obtained results between 4v4 and 5v5 game forms were found not to be different (p> 0.05) regarding the studied collective game-play variables, and offensive sequences (see table 1): duration of ball possession, number of players involved in the attack and number of actions with ball (pass, shots or all actions). However, from a pedagogical perspective the simplest game form revealed to be more appropriate, because in 4*v*4 the students were able to set up more open scoring opportunities, which at this stage of teaching is very rewarding and encouraging to learn handball. In both game forms, the average of time per ball possession was very short and the most of offensive sequences involved only one or two players. This shows a very individualized attack that might have several possible explanations: the court size is to small, reason why the reach goal easily without using support play, defenders are unable to deny individual progression which would enforce more inter-passing solutions, or the attackers do not yet understand the interplaying concepts. In 5v5 the number of passes per minute slightly increased, which seems to be related with the presence of one more player in the game and consequently less space to play and one more passing-line. In both situations, the observed number of shots was similar.

Table 1. Results of non-parametric Wilcoxon test in collective indicators and other descriptive categories.

Collective indicators	4v4	5v5	p value
Duration of ball possession (seconds)	6.42±3.36	6.02±4.34	.3
Number of actions with ball per attack	3.46±1.77	3.85±2.57	.48
Number of players involved per attack	1.5±0.67	1.75±0.78	.06
Shots/Number of ball possessions	72%	69%	
Nº of passes per minute of effective game	7.5	10.6	
Nº of shots per minute of effective game	6.7	6.9	
Number of goals / Number of shots	22%	30%	

The results of attacking actions that led to game-play advantage (figure 2) reinforce our believes that the 4*v*4 is more appropriate to introduce handball to absolute handball beginners at school.
The higher number of appropriate attacking actions with dribble-progression in 4v4, when compared with the 5v5, might be justified with increased space to progress and fewer players in the court. In the 5v5 game form a higher number of scoring attempts without reaching offensive advantage was observed. Hereby, the less available space and some lack of individual skills to play in more narrow spaces may justify the findings. However, in 5v5 were observed more situation of wide positing to build up the attack.

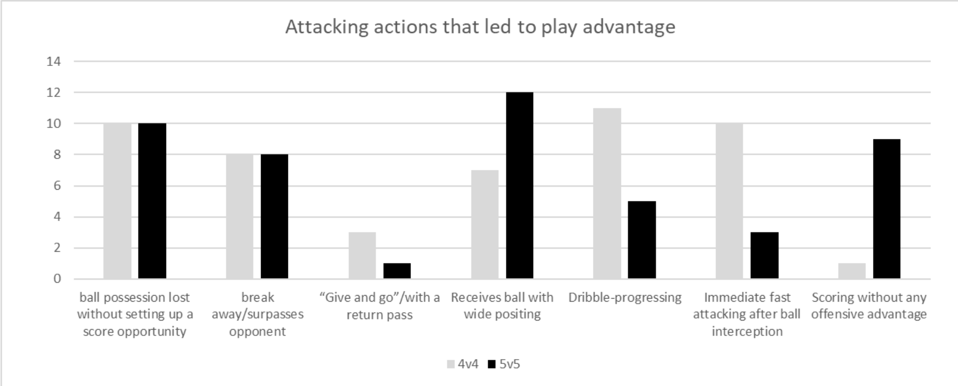


Figure 2. Results of observed number on collective indicator of attacking actions that led to play advantage in 4v4 and 5v5.

The nature of opposition observed per each scoring attempt (see figure 3) reveled that in 4v4 the students were able to set up better scoring situations (more shots with no opposition and less shots from long distance) than in 5v5. In this level of learning, one of the priorities is to focus the goal attack concept and setting up easy scoring opportunities based on transitional play. Therefore, the obtained results reinforce the pedagogical value of the usage of reduced games forms with absolute handball beginners.

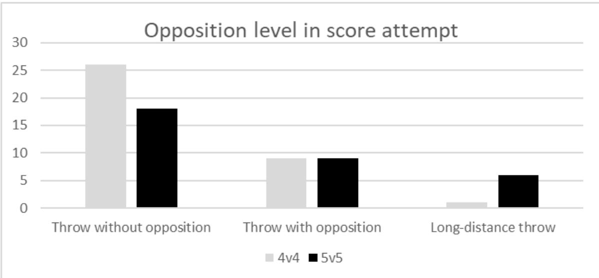


Figure 3. The count of observed number on opposition level in score attempt indicator in 4v4 and 5v5.

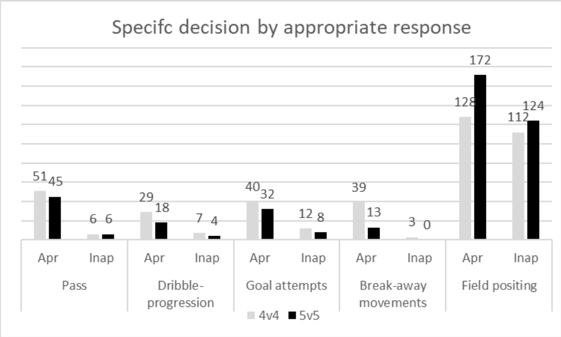
It was interesting to observe that the majority of score attempts in 4v4 occurred in the middle of the attacking zone (86%), corresponding to zone A2 and A3, while in 5v5 there was a more equitable distribution of shots through the four attack zones (A1 – 21%, A2 – 21%, A3 – 27%, A4 - 12%).

Regarding the decision-making, skill execution, effectiveness and game involvement, the results of *Wilcoxon* test not revealed a statistically differences (p> 0.05) in any variable (see table 2).

Table 2. Results of non-parametric Wilcoxon test in individual index's of HTPE categories

Individual *index's*	4v4	5v5	p value
Decision making with ball index	0.56±0.19	0.50±0.22	.33
Decision making without ball index	0.65±0.23	0.63±0.21	.84
Skill execution index	0.65±0.13	0.63±0.24	.83
Effectiveness index	0.68±0.11	0.72±0.18	.46
Game involvement (total number of actions)	15.5±10.2	12.06±8.68	.09
Actions with ball peer player	15.9±10.1	12.44±9.33	.08

From an individual point of view, a higher number of appropriated dribble-progression actions and breakaway movements (getting free without ball) were observed in the 4v4 than in the 5v5 (figure 4), what might be also related with differences in the available space to exploit.
The field positing action was increased in 5v5 game form probably related in required space rationalization and presence of one more player in attack.



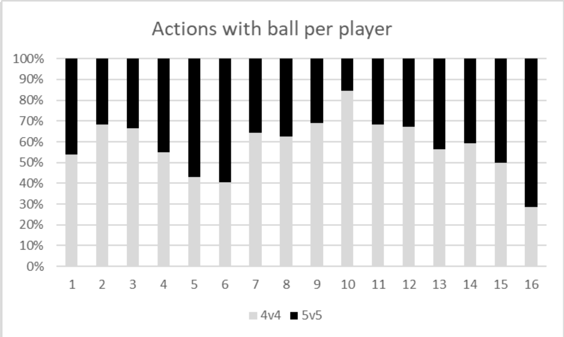


Figure 3: Results of appropriate response decision in 5 categories of HTPE and distribution graph of actions with ball per player (active involvement)

Conclusion

The results were not conclusive whether there is, or not, an instructional and learning advantage of using 4v4 in comparison with 5v5 in handball beginners. From a pedagogical perspective it makes sense to use simplest game forms, such as 3v3, plus goalkeepers (4v4), because each player will have more changes to have ball in their hands and more time-space to play.
As this was a preliminary and exploratory study, it is therefore clear that more studies are required with increased sample sizes, which in a school setting this is not always easy to reach. Another critical issue is to develop appropriate observational game play tools, from a collective and individual perspective. Without being able to identify and measure affective game play variables, we may never see significant differences between distinctive teaching approaches. This is still a very significance research challenge in game analysis in invasion sport, no matter the performance level.

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EFFECT OF PROPHYLACTIC ANKLE TAPING ON LOWER LIMB JOINT ANGLES DURING ATHLETIC TASKS

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Summary
The purpose of this study was to evaluate the differences between ankle-taped and untaped legs in knee and hip joint angles. 12 female collegiate athletes volunteered to perform landing and stopping from a jump tasks. Knee and hip flexion angles of legs with ankle taping were greater during left-leg landing, right-leg landing, double-leg landing and double-leg stopping in comparison to the untaped-leg angles except for the hip flexion angle at left-leg landing.

Keywords: anterior cruciate ligament, ankle-taping, landing, stopping, joint angle

Introduction

An anterior cruciate ligament (ACL) injury is one of the most common traumas due to athletic and recreational activities, mostly occurring during a period of 30 years (15 to 45 years of age) (Griffin et al. 2000). Considering those with knee injuries such as ACL or meniscus tear have a high risk of osteoarthritis (Lohmander et al. 2007), ACL injury exerts a serious and long-term (up to decades) influence on athletes.

A number of studies have been conducted to identify the environmental, anatomical, structural, hormonal and biomechanical risk factors for ACL injury. More than 70% of ACL injuries related to sports occur in non-contact activities, such as sudden deceleration prior to a change of direction or landing from a jump, athletes have repeatedly performed in matches or practices (Boden et al. 2000, Griffin et al. 2000, Olsen et al. 2004). Through several video analyses of the activities, it has been found a nearly full-extended knee and a straight posture consisted of decreased knee, hip and trunk flexion are primary risk factors for ACL injury (Olsen et al. 2004, Walsh et al. 2012). A decreased knee flexion angle has potential for increasing ACL loading (Besier et al. 2001). Quadriceps contract maximally when knee flexion joint angles are within 10 to 30 degree, leading anterior displacement of the tibia on the femur (Griffin et al. 2000). In addition, a straight landing posture produces greater ground reaction forces than a flexed posture (Daneshjoo et al. 2015). Griffin et al. (2000) suggested ACL strains would be less when planting or landing with the 60 degree or more flexed knee. These findings suggest it could be necessary for ACL injury prevention to keep the angle of knee and hip flexed more in athletic activities such as landing from a jump.

Prophylactic taping is designed to control the range of joint motion. It is generally used to prevent soft tissues (e.g. ligaments, tendons or muscles) of the taped area from stretching or tearing by limiting excessive range of joint motion. During landing from a jump, the ground reaction forces imposed on the body are absorbed by the lower extremity primarily. Ankle, knee and hip joints cooperatively work for the absorption. The knee and hip joint motion would be greater when the range of ankle joint motion is restricted with use of ankle taping. Several researches have investigated the biomechanical effect of ankle bracing during a drop-jump task. To our knowledge, no studies have examined how ankle taping affect on knee and hip joint motion during nearly sports-specific activities, such as stopping followed by a jump-up. Therefore, the purpose of this study was to evaluate the differences between ankle-taped and untaped legs in knee and hip joint angles in the sagittal plane during three landing and one stopping tasks. It was hypothesized that ankle taping would increase knee and hip flexion angle during four tasks.

Methods

Subjects: Twelve healthy female collegiate athletes (age = 20.33±0.9 years, height = 161.85±4.98 cm, body weight = 57.73±10.77 kg, seven basketball players and five handball players) volunteered to participate in this investigation. All subjects were active and had no lower limb injury within the last three months and no history of knee and hip joint traumas. All subjects' dominant legs were right. Subjects signed their informed consent forms prior to collecting data.

Procedures: Subjects were instructed to warm-up and practice 4 landing tasks (single (left)-leg landing (Figure 1), single (right)-leg landing (Figure 1), double-leg landing from a vertical jump (Figure 2) and double-leg stopping from a horizontal jump followed by vertically jumping (Figure 3)) for 10 minutes before video-recording. Markers were placed on each subject bilaterally at lateral malleolus, head of fibula, lateral epicondyle of femur, greater trochanter and iliac crest. Subject performed 3 trials for each task at maximal effort without ankle taping. Ankle taping, 38mm Johnson and Johnson Coach® adhesive tape (Princeton, NJ, USA), was bilaterally applied to each subject after the untaped session. The ankle taping condition included 2 anchor strips on distal leg, 3 stirrup strips, several horizontal horse-shoe strips (up to enclosing the taped area), 1 figure-eight strip and 2 heel-lock strips. Subjects performed 3 trials for each task again in the taped session. Two digital video cameras were used to obtain two-dimensional (2D) images in the sagittal plane bilaterally during trials. The 2D images of 8 (out of 24 trials) best trials were chosen for analysis. The best trial was defined as one in which the subject vertically (in single- and double-leg landing tasks) or horizontally (in double-leg stopping task) jumped the most. The knee and hip flexion angles were collected from two-dimensional images by using Kinovea, a free software application. The knee and hip flexion angles were defined as the peak flexion angles in the period at which heels were in contact on the ground during landing.

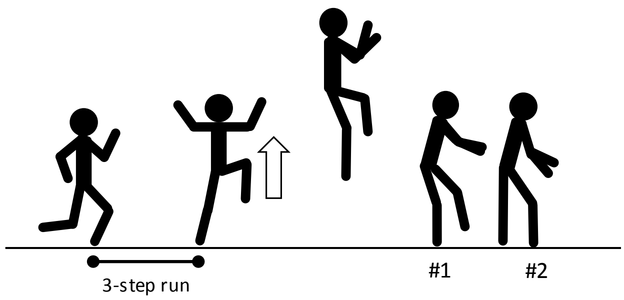

Figure 1. Single-leg landing task; the subject performed three-step run, followed by vertically jumping off one preferred foot and one-footed landing with using the second foot (opposite to initial foot for the landing) for safety. The peak knee and hip flexion angles in the period at which each heel was in contact on the ground during the best trial were measured for analysis.

#1; measured phase when initial foot landed #2; measured phase when second foot landed

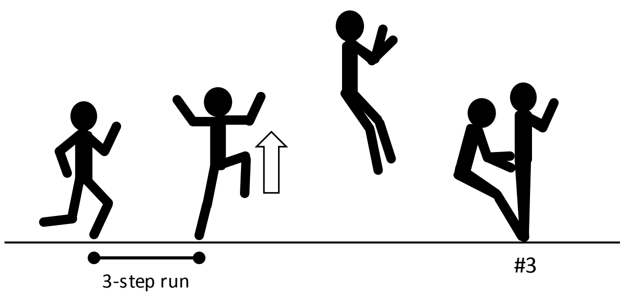

Figure 2. Double-leg landing task; the subject performed three-step run, followed by vertically jumping off one preferred foot, two-footed landing and standing up at the landing point. The peak knee and hip flexion angles in the period at which heels were in contact on the ground during the best trial were measured for analysis.

#3; measured phase when both feet landed simultaneously

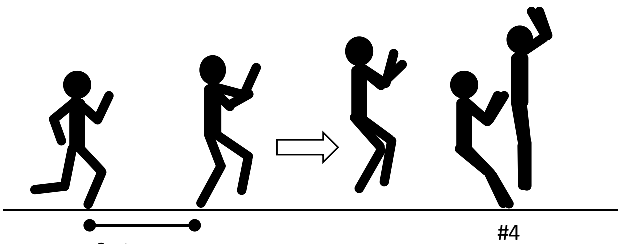

Figure 3. Double-leg stopping task; the subject performed three-step run, followed by horizontally jumping off one preferred foot, two-footed landing and vertically jumping off the landing point immediately after landing. The peak knee and hip flexion angles in the period at which heels were in contact on the ground during the best trial were measured for analysis.
#4; measured phase when both feet landed simultaneously

Statistical analysis:
All data obtained are shown as mean ± SD. The data was calculated statistically by using the Wilcoxon Signed-Rank test to compare the variables between the sessions (taped and untaped) with $p<0.05$ as statistical significance. The Statistical Package for Social Sciences (version 21.0 Statistical Base, SPSS, Inc., Chicago, IL, USA) was used.

Results and Discussion
The results are shown in Table 1, Table 2 and Table 3. The knee flexion angle of the ankle-taped leg (right) was significantly greater than the untaped leg (right) during the single (right; initial foot and left; second foot) -leg landing ($p<0.01$ and $p<0.01$, respectively), the double-leg landing ($p<0.01$) and the double-leg stopping ($p<0.01$). The knee flexion angle of the ankle-taped leg (left) was significantly greater than the untaped leg (left) during the single (right; second foot and left; initial foot) -leg landing ($p<0.05$ and $p<0.01$, respectively), the double-leg landing ($p<0.01$) and the double-leg stopping ($p<0.01$). There were significant differences between the taped leg and the untaped leg in the knee flexion angle in all tasks.

Table 1 Knee and hip flexion angle during the single-leg landing from a vertical jump

variable	session		p-value
	untaped	taped	
Knee flexion angle of the right (initial) leg during single (right) -leg landing	63.7 (7.4)	70.8 (5.7)	< 0.01
Knee flexion angle of the left (second) leg during single (right) -leg landing	54.8 (7.1)	64.2 (11.4)	< 0.05
Hip flexion angle of the right (initial) leg during single (right) -leg landing	50.2 (9.0)	60.3 (14.0)	< 0.05
Hip flexion angle of the left (second) leg during single (right) -leg landing	69.7 (15.3)	78.4 (16.1)	< 0.05
Knee flexion angle of the left (initial) leg during single (left) -leg landing	62.7 (6.2)	76.4 (8.7)	< 0.01
Knee flexion angle of the right (second) leg during single (left) -leg landing	57.3 (9.7)	69.9 (11.6)	< 0.01
Hip flexion angle of the left (initial) leg during single (left) -leg landing	51.3 (6.7)	58.8 (15.1)	n.s.
Hip flexion angle of the right (second) leg during single (left) -leg landing	72.8(9.0)	82.3 (18.8)	n.s.

The hip flexion angle of the untaped leg (right) was also significantly less than the taped leg (right) during the single (right) -leg landing ($p<0.05$), the double-leg landing ($p<0.01$) and the double-leg stopping ($p<0.05$). The hip flexion angle of the untaped leg (left) was significantly less than the taped leg (left) during the single (right) -leg landing ($p<0.05$), the double-leg landing ($p<0.01$) and the double-leg stopping ($p<0.01$). The angle of hip joint at initial contact from a jump was significantly increased by use of ankle taping in any athletic task except for single (left)-leg landing task. These findings indicated ankle taping widened the range of motion of knee and hip during landing from a jump. Yu et al. (2006) reported active hip and knee flexion motions lowered the ground reaction forces rather than large hip and knee flexion angles during two-footed landing from a vertical jump off 5-step run followed by vertically jumping. It has been found ankle taping is effective to reduce internal rotation and varus impulses of knee joint during running and sidestepping (Stoffel et al. 2010).

Table 2 Knee and hip flexion angles during the double-leg landing from a vertical jump

variable	session		p-value
	untaped	taped	
Knee flexion angle of the right leg during double-leg landing	63.4 (9.7)	75.4 (10.1)	< 0.01
Knee flexion angle of the left leg during double-leg landing	63.4 (5.0)	77.8 (7.4)	< 0.01
Hip flexion angle of the right leg during double-leg landing	63.2 (15.5)	74.6 (12.2)	< 0.01
Hip flexion angle of the left leg during double-leg landing	65.5 (13.7)	73.2 (15.4)	< 0.01

Table 3 Knee and hip flexion angles during the double-leg stopping from a horizontal jump

variable	session		p-value
	untaped	taped	
Knee flexion angle of the right leg during double-leg stopping	69.2 (6.1)	73.4 (5.5)	< 0.01
Knee flexion angle of the left leg during double-leg stopping	70.6 (6.7)	77.6 (8.3)	< 0.01
Hip flexion angle of the right leg during double-leg stopping	69.1 (8.9)	76.1 (8.8)	< 0.05
Hip flexion angle of the left leg during double-leg stopping	64.7 (10.2)	74.1 (12.8)	< 0.01

The results of the current study suggest ankle taping may be effective to reduce ACL injury risk in athletic activities. However, Stoffel et al. reported ankle taping increased valgus impulse, one of primary risk factors of ACL injury, in some athletic tasks. Further studies are required to clarify the effectiveness of ankle taping for ACL injury prevention.

There are several limitations recognized within this study. First, the biomechanical data of this study were examined by analyzing 2D images. 3D approach is required to obtain more accurate data. Secondly, our investigation was conducted to only sagittal plane biomechanics. Frontal and transverse plane biomechanics, such as valgus and internal moment, should be analyzed. Thirdly, the short-time effects were discussed in this study. The restriction of joint motion by using taping is gradually weakened over time. The long-term effect of ankle taping on knee biomechanics during athletic activities also should be addressed in future analysis.

Conclusion

The results of the present study found that taped ankle increased the knee and hip flexion angle during single- and double-leg landing form a vertical jump and stopping from a horizontal jump. This is likely due to restriction of ankle joint motion with ankle taping. Ankle taping may be potential to provide helpful posture to prevent ACL injury.

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IMPORTANT ABILITIES WHICH MAY FACILITATE THE SOCIAL INTEGRATION IN A HANDBALL TEAM

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Abstract
To be popular in a group or in a sports team can be important, but to be rejected must be avoided. The present research focused on identifying important motor abilities of the informal leader, in the case of preadolescent handball players. Numerous research evidence were gathered over many decades of measuring children's peer popularity using the sociometric technique. Sociometric research typically involves that group members choose other members in the group, based on specific criteria. The two types of sociometric criteria used in our peer assessment were: reputational (objective assessment of an individual's sport-related competence, performance and abilities) and emotional (involving personal, subjective evaluations). In our study have participated 15 athletes and represented the „reference group", within which status was determined. Relevant motor skills of the athletes were evaluated through the following specific motor ability tests: 30 m run test, 30 m slalom dribble test, shuttle run test, throwing the handball ball at distance and standing long jump. Using the Spearman correlation there have been important relations highlighted between the results obtained by the athletes at the specific tests and the preferential status index. The results point out important abilities of the informal leader, which can be developed and may have a positive influence on the social integration of the handball players in the team, at this age level.

Keywords: social integration, sociometry, informal leader, motor abilities, handball

Introduction

It is well known that the handball game attracts a large number of people, both through direct and indirect participation and, moreover, challenges people around the world to admire the idols of sport and stimulate them to self-improve (Taborski, 2011, p. 7). Building a handball team, as a functional and performing body is a complex challenge, according to modern trends in physical education and sports (Tomlinson, 2010; Papaioannou and Hackfort, 2014), which support the idea, that in order to achieve certain performance standards, it is necessary to integrate the talent, abilities, members' creativity and the optimal interaction of athletes on the field. The difference between a group and a sports team is that the team is more than just a group of people with common goals and goals. The superiority of the team is given by the fact that all individual contributions are considered complementary, the action of individuals is interdependent and coordinated and each member has a specific role (Zlate, 2004). Specialized literature states that in any given sports team there are various roles and responsibilities that have to be accomplished, in order that the team may be successful (Cotterill, 2013, p. 47). In the sports field, many studies indicate that in each team there are individuals who succeed in solving tasks, or making things happen and they also manage to mobilize their teammates to work harder (Smart, 2010, p. 27). They represent the team's "engines" that ensure the achievement of objectives and are considered to be leaders by their teammates, thus occupying a key position within the group (Stone, 2003, p. 59). Recent sport-related studies (Griffin, Phillips & Gully, 2014, p. 265) argue that most efficient groups and successful teams have a leader, nominated by the coach (formal leader) or chosen by team members (informal leader). The second, the informal leader, is the individual who has power over team members, gained through his competent work, passion, motor abilities and other skills that make him to be perceived as the best player in the team (Dahlkemper, 2013, p. 138). It was found that sporting abilities are positively associated with team leadership (Eklund & Tenenbaum, 2014). In a sports group, we can

appreciate and understand the dynamics of relationships between athletes by observing their collaboration in training lessons, in solving a task, in leisure time (extra-sporting activities) to which we can add individual or collective conversation. A higher degree of precision and rigor when appreciating the relations within a group is given by the sociometric method (Şerban, 1987). To evaluate social relationships and popularity among members of a social group, sociometric technique is generally used. Jacob Moreno (1960), considered to be "the father of sociometry", appreciates the sociometric test as an instrument that investigates social structures by measuring the attractions and rejections that exist between individuals within a group. The nomination of colleagues within a group (peer nomination), although the oldest, is the most commonly used sociometric technique (Frick, Barry & Kamphaus, 2010, p. 214) and requires the participants to select one or more of their colleagues who manifest a specific characteristic (the most liked, the one having the best marks, the best friend, the leader etc). Moreno (1934, p. 20) describes two major types of sociometric criteria: emotional and reputational. The emotional criterion mostly regards a personal, subjective evaluation, while the reputation criterion requires an objective assessment of the individual's competence or reputation (Rubin, Bukowski & Laursen, 2011, p. 86). Specialists (Verza & Verza, 2000, p. 182), assert that at the stage of preadolescence, choosing playmates is done not by sympathy, but rather by the qualities that a child manifests durring a game. This aspect is also reflected in the post-game discussions about the contribution given by each participant to the succes of the team. Consistent judgments are made and rigurous feedback is provided to each of the play partners, about the capabilities and skills shown durring the game.
The current study aims at identifying important motor abilities (speed, strenght, coordination and endurance) which may facilitate the social integration (expressed through the value of the preferential status index) of preadolescent athletes in a handball team.

Materials and methods

Participants
A total number of 15 female athletes, aged between 10 and 11 years old, practicing handball have participated at the research. The 15 junior handball players, having a training experience comprised between 3 and 4 years, represented the "reference group" within which the preferential status was determined.

Apparatus and materials
Relevant motor skills of the athletes were evaluated through the following specific motor ability tests: 30 m run test, 30 m slalom dribble test, shuttle run test, throwing the handball ball at distance and standing long jump. The athletes performed each test twice, the best performance being registered. Also, SPSS 20 was used for statistical processing of data.

Procedure
The research was conducted with all the 15 handball players at a time, in the same order, at about same time of the day (in the afternoon). The sociometric test was performed with all team members being in a repaus state (without previously being engaged in any physical activity). Ethical considerations impacted on the research and ethical guidelines were rigorously adhered to throughout the research (Denscombe, 2014, p. 318): the athletes' participation was voluntarily; they were all informed that, at any point, they could decide to withdraw from the research; anonymity of the participants was ensured and data has been treated confidentially.
The 30 m run test (Hantău, 2004, p. 151) is used for the assessment the speed on short distance. Materials: 4 cones, adhesive tape and stopwatch. Protocol: Measure the distance of 30 m and mark with adhesive tape the starting and the arrival line; place two cones at a distance of 1 m between them both on the starting line and on the finish line; departure will be done at will, the stopwatch starts at the first move and stops when the finish line is crossed. Results: Each player has the right to two attempts, taking into account the best; time is expressed in seconds and miliseconds.

The 30 m slalom dribble test is designed for the evaluation of ball handling in dribbling and coordination. Materials: 11 balls, adhesive tape and a stopwatch. Protocol: On the length of the handball field, are placed in a straight line 7 marking poles with a height of 1.5 - 1.8 m, as follows; the first cone at a distance of 6 m from the starting line and the last 6 m before the finish line; between these poles are placed the other five poles from 3 to 3 m; the start and finish lines are marked with adhesive tape and two cones; the participants have to cross the 30 m in multiple dribbles, as the ball must be permanently controlled during the test; the finish line must be passed with the ball in dribbling; the timer starts at the first move and stops when the player crosses the finish line. Results: the result is recorded in seconds and miliseconds; two attempts are made, taking into account the best time.

The shuttle run test is conceived for the assessment of the endurance on short and repeated distances; Materials: adhesive tape, 2 balls and a stopwatch; Protocol: the distance of 10 m it is measured and marked by two circles on the ground; In one circle are the two balls; the player starts from the free circle, runs and takes a ball from the other circle and brings it to the circle from which he starts, then repeats the same exercise; the timer starts at the first movement and stops when the second ball lands in the starting circle. Results: Each player is entitled to two attempts, the best result being noted; the result is expressed in seconds and miliseconds.

Throwing the handball ball at distance test is intended to assess the upper limb explosive power. Materials: two cones, adhesive tape, roulette, handball ball; Protocol: use age-appropriate ball (number 0); the ball will be thrown at distance after a three-step advance pitch; throwing will be done from the back of a line drawn on the ground, a line that can not be exceeded until the moment when the ball leaves the hand; it can be used any succession of steps. Results: two throws will be executed and the best result will be retained; the result will be expressed in meters and centimeters.

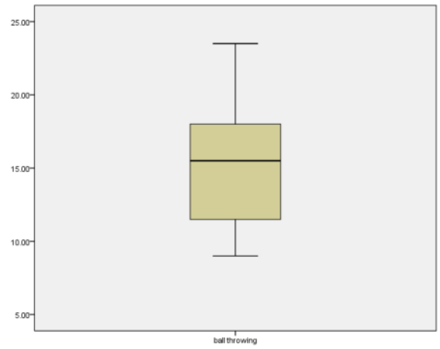
The standing long jump test evaluates the explosive power of the lower extremities. Materials: graduated scale, adhesive tape (to mark the starting line). Protocol: the participant, from standing position start the jump on both legs in length; the distance between the starting line and the heel position after landing is measured; Results: expressed in centimeters, retaining the best performance from three attempts.

The peer nominations procedure, which is the oldest sociometric technique was used in order to identify the informal leaders and the existing relations between the members of the team (handball players). The participants were solicitated to answer two questions by nominating a person from their peer group who best fits the specific investigated criteria: reputational and emotional. For the reputational criteria – the athletes had to assess through peer nomination: the performance, competence and abilities, indicating in this way the sport „task-specialists“ (Daft & Marcic, 2011) and „non-specialists“. The questions were: *Who would you like to have on your team?* and *Who you wouldn't like to have on your team?* (both questions were concerning a handball competition). They were asked to indicate, for each question, three peers, according to the manifested performance, competence and abilities in the context of handball. For the emotional criterion we used the questions: *Who would you like to go on a trip with you?* and *Who you wouldn't like to go on a trip with?* (both questions were related to a field trip outside the city). Based on the matrix of sociometric selections, for each member within each team, we were able to calculate the preferential status index (Predoiu, 2016) and consequently to appoint each player to one of the following groups: *popular* (athletes who obtained positive values of the preferential status index), *neglected and controversial* (the value for the preferential status index was 0; *neglected* meaning that they weren't nominated at all, *controversial* being evidence that they were given the same moderate number of positive and negative nominations from their peers) and *rejected* (players which obtained negative scores for the preferential status index).

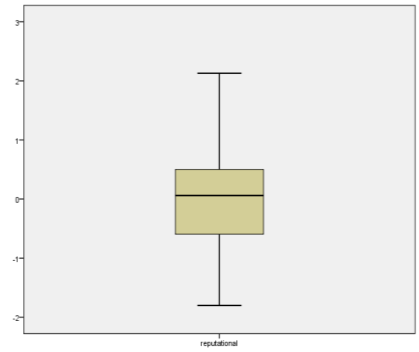
The results obtained by the athletes at the: 30 m run test, 30 m slalom dribble test, shuttle run test, throwing the handball ball at distance and standing long jump test were correlated with the results concerning the preferential status index registered for each team member (for both reputational and emotional criterion).

Results

The box-plot charts, in the preliminary data analysis revealed that for the scores obtained by the female handball players at: 30 m run test, 30 m slalom dribble test, shuttle run test, throwing the handball ball at distance and standing long jump test, there were no extreme values (outliers) found (Figure 1).



(a)



(b)

Fig. 1. Extreme values (a) ball throwing at distance; (b) preferential status index (reputational criterion)

Using the Spearman correlation there have been important relations underlined between the results obtained, in the case of the handball players, for 30 m run, shuttle run, throwing the handball ball at distance, standing long jump and the preferential status index (regarding the reputational criterion – concerning the athletes' performance, abilities and efficiency in handball settings and the emotional criterion). The conditions for the application of the Spearman correlation we mention that were fulfilled (Labăr, 2008: 87): both variables are ordinal or one of them is quantitative and the other ordinal; the sample does not have a large volume (15 athletes); the scores of a variable are monotonously related to the scores of the other variable, meaning that, once the values of a variable register growth, the values of the other variable will also grow (decrease) – but not necessarily in a linear manner.

Table 1. Results for 30 m run, 30 m slalom dribble, shuttle run, throwing the handball ball at distance, standing long jump and the preferential status index (reputational criterion)

Variables	Athletes	Mean	Standard Deviation	Standard Error	status index (reputation) Spearman's rho Correlation Coefficient
status index (reputation)	15	-0.008	.976	.252	1.000
30 m run	15	5.663	.440	.113	0.651**
30 m slalom dribble	15	10.394	1.434	.370	0.257
shuttle run	15	12.393	.878	.226	0.594*
throwing the ball at distance	15	14.966	4.146	1.070	0.746**
standing long jump	15	144.66	16.087	4.153	0.798**

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

The statistical analysis of the results presented in table number 1 has shown that:

- There is a positively significant correlation (0,651) between the 30 metres sprint ability (speed on short distance) and the scores obtained by the handball players for the preferential status index regarding the reputation ($p < 0,05$). Regarding correlation, a relevant indicator for the effect size index is the determination coefficient (r^2) whose value is 0,42. Thus, 42% of the variation of the two variables is considered to be common, the rest being a result of other influences. We can assert that the relation between the short distance sprint ability and the preferential status index, considering the performance, skills and efficiency on the handball court, is moderated to strong.

- A positively significant correlation (0,594) between the ability to perform intense exercise repeatedly (short distance repetead sprint, endurance) and the value for the preferential status index regarding reputation ($p < 0,05$). The determination coefficient (r^2) has a 0,35 value, which points out that the relation between the ability of performing intermittent sprints and the results for the preferential status index, in the case of athletes' reputation, is moderated to strong.
- There is a positively significant correlation (0,746) between the ability to throw the handball ball at distance (speed-strenght capacity) and the scores obtained by the handball players for the preferential status index - reputation ($p < 0,05$). In this case, the determination coefficient (r^2) has a 0,55 value, meaning that the relation between the ability to execute speed-strenght movements and the preferential status index regarding athletes' reputation, is strong.
- Also, there is a positively significant correlation (0,798) between the explosive power of the handball players and the value of the preferential status index, regarding reputation ($p < 0,05$). The determination coefficient (r^2) has a 0,63 value, meaning that the relation between the ability to execute movements requiring explosive power of the lower extremities and the preferential status index regarding athletes' reputation, is strong.
- Between the slalom dribble on 30m distance ability (coordination) and the preferential status index (regarding reputation) no statistically significant correlation was found.

Table 2. Results for 30 m run, 30 m slalom dribble, shuttle run, throwing the handball ball at distance, standing long jump and the preferential status index (emotional criterion)

Variables	Athletes	Mean	Standard Deviation	Standard Error	status index (emotional) Spearman's rho Correlation Coefficient
status index (emotional)	15	-0.233	.666	.172	1.000
30 m run	15	5.663	.440	.113	0.251
30 m slalom dribble	15	10.394	1.434	.370	0.161
shuttle run	15	12.393	.878	.226	0.716**
throwing the ball at distance	15	14.966	4.146	1.070	0.671**
standing long jump	15	144.66	16.087	4.153	0.794**

**. Correlation is significant at the .01 level (2-tailed).
*. Correlation is significant at the .05 level (2-tailed).

The analysis of the results shown in table number 2 has undelined that:
- There is a positively significant correlation (0,716) between the ability of performing intermittent sprints (endurance) and the results for the preferential status index, concerning the emotional criterion ($p < 0,05$). Regarding correlation, the determination coefficient is $r^2 = 0.51$, highlighting a strong relation between the ability to perform short sprints repeatedly (intermittent effort) and the scores for the preferential status index (emotional evaluation).
- Between the ability to throw the handball ball at distance (speed-strenght capacity) and the scores obtained by the handball players for the preferential status index (emotional), there is a positively significant correlation $r = 0,671$, $p < 0,05$. The determination coefficient is 0.45, which indicates a moderated to strong relation between the capacity to execute actions which require upper limb explosive power and the preferential status index (emotional assessment).
- There is also, a positive positively significant correlation (0,794) between the explosive power of the lower extremities of handball players and the results for the preferential status index, concerning the emotional criterion ($p < 0,05$). The calculated determination coefficient is 0.63, which emphasize a strong relation between the capacity to perform actions which require explosive power of the lower extremities and the preferential status index (emotional assessment).
- We mention that, between the 30 metres sprint ability (speed on short distance), slalom dribble on 30m (coordination) and the preferential status index (emotional criterion) no statistically significant correlations were found.

Concerning the two criteria used in our research, we found out that the most elected players by their teammates regarding the reputational criterion were also the most elected in the case of emotional assessment. Moreover, the leader elected considering the reputation was the same person designated by the peer group as leader regarding emotional criterion.

Discussions and conclusions

The present research results have demostrated the existence of positively significant correlations between important motor abilities, speed, strenght, coordination and endurance and the social status (assesed through the sociometric test and expressed by the preferential status index). Concerning the positive significant correlations between the ability of speed on short distance (result of 30 m run test), endurance on short and repeated distances, speed-strenght capacity, the explosive power of the lower extremities and the preferential status index (regarding reputation), we can say that these motor abilities may have an impact on the social status of a player in a handball team or upon it's inclusion in a specific group (popular/ accepted, controversial/ neglected or rejected). This aspect can be explained by the fact that, at this young age, choosing playmates is made in relation to the qualities, abilities and contributions of a child durring a small game, durring practice or in competitions. That can also explain the fact that there were found positively significant correlations between the endurance on short and repeated distances, the upper limb explosive power (speed-strenght), the explosive power of the lower extremities and the preferential status index (social status assessed using emotional criteria) of preadolescent handball players. This study finding underlines the fact that, at preadolescent age, it is not entirely relevant the criterion used (reputational or emotional) since the results weren't that different. The results of the present research emphasize the important role of the motor skills (speed on short distances, endurance, explosive power of the lower and of the upper limbs) for the social integration in a handball team, at this young age. Based on the study results, we can say, that if the female preadolescent handball players improve their motor skills (speed, endurance, strenght and explosive power) through specific training, this aspect can be related with a better social integration in the handball team. Thus, our research results ensure useful information, that can be used by the sport specialists, which can develop specific stimulation programs for the training of the athlete's motor abilities that may facilitate the young handball players' social integration. We acknowledge that the study findings although interesting, they present only a limited understanding of how motor abilities contribute to the social integration of a player in a handball team. We've investigated only a part of the motor skills in a specific context (young female handball players). The limitations of our research were constituted of: characteristics of the sample of participants (small sample size, gender, age and competitive experience), the physical and mental state of the athletes in the testing moment (fatigue or affective-motivational factors), the social and cultural context and also, the specific features of the examined sport branch – handball. Consequently, the interpretation of the results requires that the results be interpreted cautiously, future research being needed on larger samples, having different ages, from various environments or practicing different sports, in order that generalizability could increase. The present study can be viewed as a starting point for future and wider research regarding motor abilities and their role in facilitating the social integration in a handball team.

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All authors have equally contributed to this article.

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EFFECTS OF COMBINED RESISTANCE AND SPORT-SPECIFIC DRILL TRAINING VERSUS RESISTANCE TRAINING OR SPORT-SPECIFIC DRILLS ALONE ON FITNESS PERFORMANCE CHARACTERISTICS OF HANDBALL PLAYERS

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Abstract
The ability to maintain a high technical efficiency during resistance exercise is an important feature of the successful handball player (DelloIacono et al. 2016).Thus, training plans should take due account of the required handball skill and the seasonal periodization of player preparation. The purpose of this study was to compare the effect of combined resistance-training and handball-specific-drill (RSS) versus resistance-training program and no handball-specific drill training (RTS) and handball specific drill training only (SSC).

Keywords: maximal strenght, throwing performance, specific training, resistance training

Introduction

The physical demands of modern handball include running, jumping, sprinting, throwing, hitting, blocking, and pushing (Massuca et al. 2014; Hermassi et al. 2016). A match requires high-impact intermittent exercise, with many lateral movements, jumps, and throws (Massuca et al. 2014; Wagner et al. 2014). The maintainingthe technical skills of players is a dominant concern, and since training time is at a premium, coaches are increasingly relying on an integrated approach to conditioning and skill-based work (Corvino et al. 2014).

The use of such drills has been reported as yielding physiological responses that mirrored aspects of both average and maximal match play, and this pattern of training has been recommended as a means to improve fitness levels in advanced players (Corvino et al. 2014). However, only a few studies have investigated sport-specific training in handball players participating in intermittent sports (i.e., soccer and handball)(Buchheit et al. 2009) and no previous study has been conducted in elite handball players. To date, most studies ofhandball players have looked atthe effects of either high-intensity “aerobic training” (Buchheit et al. 2009) “mixed”, i.e., repeated shuttle sprints, (RSS)(Iacono et al. 2015), or match-based, i.e., small-sided games (SSG) (Buchheit et al. 2009). Moreover, this pattern of training mirrors the intermittent nature of handball play, requiring players to train using typical physiological demands (i.e., accelerations, decelerations, changes of direction, jumping and throwing) (Hermassi et al. 2017).

SSG can develop physical capacities together with sport-specific tactical and technical skills (Buchheit et al. 2009), replicating the movement patterns, physiological demands and technical requirements of competitive matches (DelloIacono et al. 2016), while also requiring players to make decisions under conditions of pressure and fatigue. In addition, SSG training is thought to increase player compliance and motivation, since it is perceived as a sport-specific exercise that maximizes the training time spent with the ball. We thus tested the hypothesis that elite handball players who supplemented their normal in-season handball training with an 8-week biweekly program of RSS and RTS for both the upper and lower limbs would enhance their muscular strength and explosiveness without compromising other factors critical to handball performance (maximal strength, throwing velocity, sprinting, jumping abilities and balance).

Methods

Subjects

Thirty-two top-level male out-field handball players (age: 18.6 ± 0.5 years, body mass: 84.2 ± 3.1 kg, height: 1.77 ± 0.07 m, body fat: 13.4 ± 0.4%) agreed to participate. All were drawn from a single team in the top National Handball League. Their mean handball experience was 8.2±0.8 years and eight of the group were left-handed. All were in good health and before beginning the study they passed amedical examination provided by the team physician with a particular focus orthopaedic and other conditions that might preclude resistance training.

1-RM Pull-over (1-RM_{PO})

A full description of the pull-over exercise has been provided by Hermassi et al. (2017). The bar was positioned 0.2 m above the subject's chest, supported by the bottom stops of the device. Successive eccentric-concentric contractions were performed from the starting position. All subjects were familiar with the required technique, having used it in their weekly training sessions. A pre-test assessment of 1-RM_{PO} was made during the final standard training session. For RM_{PO} as for the RM_{BP} (below), warm-up for the definitive test comprised five repetitions at loads of 40–60% of the pre-test RM_{PO} and RM_{BP}. Thereafter, four to five separate attempts were performed until the subject was unable to extend the arms fully on two occasions. The load noted at the last acceptable extension was considered as the 1-RM_{PO}. Two minutes of rest were allowed between trials.

1-RM Back Half Squat at 90 degree flexion

The bar was grasped firmly with both hands and was also supported on the shoulders. The knees were bent to 90 degrees and the subject then regained the upright position, with the legs fully extended. Eight technical training sessions were performed during the month preceding definitive measurements. After 2 successful repetitions at the pretest RM, a further 1-kg load was added. If the second repetition could not be completed at the new loading, this was accepted as the individual's 1-RM. Typically 3 to 6 lifts were needed to reach the 1-RM.

Squat Jump and Counter Movement Jump

Characteristics of the SJ and the CMJ (jump height, maximal force before take-off, and average power) were determined by force platform (Quattro Jump, version 1.04; Kistler Instrument AG, Winterthur, Switzerland). Jump height was determined as the center of mass displacement, calculated from the recorded force and body mass. Subjects kept their legs absolutely straight throughout flight. They began the SJ at a 90 degree knee angle, avoiding any downward movement, and performed a vertical jump by pushing upward on their legs. In the CMJ, they began from the upright position, making a downward movement to a 90 degree knee angle and simultaneously beginning the push-off. The largest of 3 jumps was recorded for each test.

Handball throwing

A jump throws and a 3-step running throwwere evaluated on an indoor handball court. Throwing time was recorded with an accuracy of 1 ms, using a digital video camera (SONY, HVR –A1U DV Camcorder, Tokyo, Japan). The camera was positioned on a tripod 3 m. Data processing software (Regavi&Regressi, Micrelec, Coulommiers, France) converted measures of handball displacement to velocities.

Training program

Participants added 3 training sessions per week to their usual training requirements for 8 weeks. During the training sessions between RSS and SSC, body contact between players was avoided, since thiscould have affected the results obtained. The experimental training programs (RSS & RTS) followed a periodized plan, with overload, progression, and a short tapering period (i.e., 4 days) to maximize final performance. The RSS regimen consisted of 3 session/wk of combined resistance-training and handball-specific-drills, whereas the RTS program consisted of 3 sessions/wk of resistance-training without handball-specific drills.

Statistical Analyses

Statistical analyses were carried out using the SPSS 20 program for Windows (SPSS, Inc, Chicago, IL, USA). Normality of all variables was tested using the Kolmogorov-Smirnov procedure. Means and SDs were calculated, using standard statistical methods. Training-related effects were assessed by 2-way analyses of variance with repeated measures (group x time). If a significant F value was observed, Tukey post hoc procedure was applied to locate pair-wise differences. We accepted $p \leq 0.05$ as our criterion of statistical significance, whether a positive or a negative difference was seen (i.e., a 2-tailed test was adopted). Percentage changes were calculated as ([post-training value - pre-training value]/pre-training value) x 100.

Results

There were significant interaction effects (group x time) in all (16) parameters. The largest interaction effect was detected for throwing performance (effect sizes equal to 0.729, 0.725 and 0.684) for jump throw, 3-step running throw and medicine ball throw respectively. The lowest interaction effect was for the half back squat (η^2=0.148, Figure1). There were also significant time effects for all parameters except body mass and % body fat.

Both experimental groups (RSS and RTS) significantly improved their balance performance comparatively to SSC. The RSS group also improved its standing stork test performance ($p \leq 0.05$) relative to RTS.

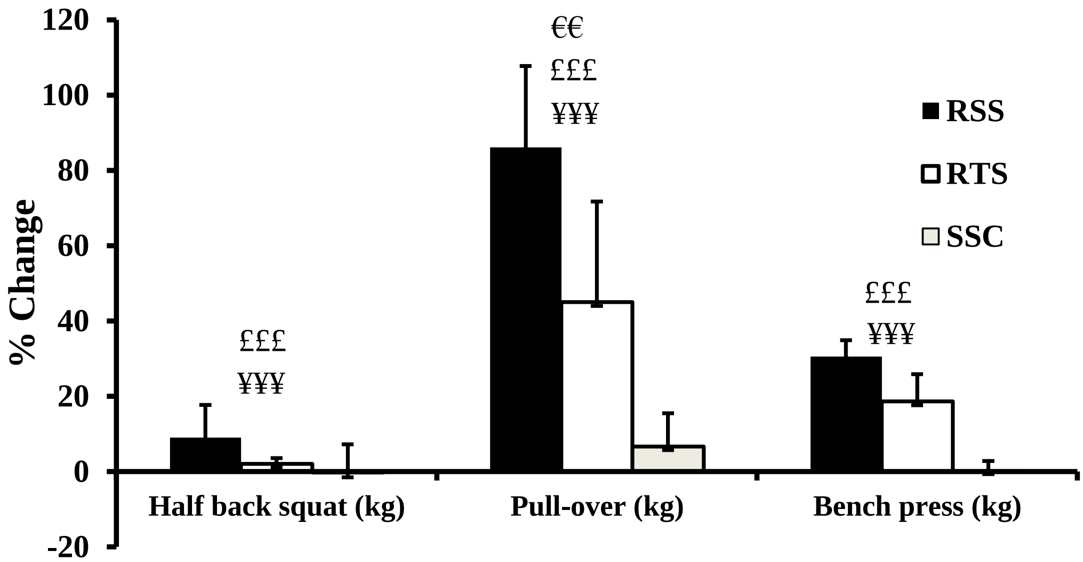

Figure 1. Training associated changes in upper and lower limb strength

Notes:

RSS = resistance-training and handball-specific-drills;

RTS = resistance-training without handball-specific drills;

SSC = handball specific drills only;

¥: denotes a significant interaction (group x time) difference between RSS and SSC

€: denotes a significant interaction (group x time) difference between RTS and SSC

£: denotes a significantinteraction (group x time) difference between RSS and RTS.

¥¥¥: $p \leq 0.001$;€€: $p \leq 0.01$; €€€: $p \leq 0.001$; £: $p \leq 0.05$;£££: $p \leq 0.001$.

Discussion

In the present study both RSS, RTS training significantly improved all performance measuresover the 8-week intervention, but with different and specific adaptations to each regimen. The RSS group achieved the largest effect sizes in 12 of the 16 parameters. Greater improvements in maximal strength of the upper and lower limbs, RSA performance, ball velocity, medicine ball throw, SJ and CMJ height were all observed, whereas the maximal strength of the lower limbs and % body Mass were not improved over the 8-week training program.

Several previous studies have identified sport-specific drillsas an effective method ofimproving aerobic-fitness characteristics in intermittent sports (soccer, handball) (Buchheit et al. 2010; Dellal et al. 2008), but to the best of our knowledge, the currentstudy is the first to investigate the effectiveness of training using a combination of resistance and sport-specific drills versus circuit resistance training without sport-specific drills as a means ofincreasing the physical fitness of elite handball players.

The present results showed that both training interventions significantly increased maximal strength in the upper and lower limbsand enhanced muscle explosiveness (CMJ, SJ medicine ball throw, and ball velocities) in these handball players relative to the to SSC group (where performance only improved on 2 of 16 parameters (pull over: d=0.82; squat jump: d=0.74). These results are in accordance with previous studies comparing small-sided games and high intermittenttraining runs, showing that both are equally effective modes of aerobic interval training in young soccer and handball players(Buchheit et al. 2010; Harrison et al. 2015). Greater effects were seen after the combination of resistance training and sport-specific drills (RSS group) and resistance training alone (RTS group) (both with large effect sizes). In this regard, Shalfawiet al. (2013) recently reported similar results in female soccer players; benefits were seen from resisted agility and repeated sprint training and from strength training, but small-sided games alone did not produce the same benefits.

Vertical jumping is frequent in both defensive (e.g., blocking, rebounding, and stealing) and offensive (e.g., passing, rebounding, and shooting) handball maneuvers. In line with previous research (Hill-Haas et al. 2009; Hermassi et al. 2017), neither of the training programs significantly improvedvertical jump height (CMJ and SJ) for the RSS and RTS groups. This could be related to the lack of overload. However, there was a large enhancement (+9.2% and +8.7% vs. +6.8% and +11.4% respectively) in the CMJ and SJ performances for RSS and RTS groups. This could be related to the similar actions (i.e., acceleration and deceleration) required during both jumping and training.

The current investigation revealed significant improvements in throwing in both groups following training. Yet RSS training proved superior to RTS in enhancing throwing, whereas there was an opposite trend for jump shot results. This study demonstrated a considerable jump shoot and 3-step running throw (+45%; +33%, $p<0.001$ and +21%; +23%, $p<0.01$ respectively) increase of throwing velocity for the RSS group compared with the RTS group,which was not surprising since earlier studies with lesser increases of workload and regular weighted balls showed increased ball velocity in experienced players after training (Ettema et al. 2008; Hermassiet al. 2011). Our results seem in accordance with the findings of Gorostiaga et al. (2005), who noted a significant enhancement ($p<0.001$) of standing handball throwing velocity after 6 weeks of heavy upper limb resistance training. However, the training exercises used by these last authors were the supine bench-press, half-squat, knee flexion curl, leg-press and pec-dec, quite different exercises from those used in the present study.

The present study demonstrated that an 8-week in-season intervention, including either RSS or RTS training three sessions a week, improved maximal strength, jumping performances and ball velocity of elite adult handball players. Specifically, RSS appeared more effective than RTS or SSC in improving fitness performance of elite players. Coaches and athletes are thus strongly encouraged to integrate these conditioning methodologies into the planning of regular handball training, with both RSS and RTS representing practical means of achieving peak performance before crucial matches such as play offs, tournaments, and national/international competitions. In addition, both RSS and RTS may be used as specific training methods to yield long-term adaptations of handball agility, jumping capability, and short sprint performances.

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VALIDATION OF THE HANDBALL-SPECIFIC COMPLEX-TEST AND NONSPECIFIC FIELD TESTS BY MEANS OF A MATCH PERFORMANCE SCORE IN ELITE PROFESSIONAL HANDBALL PLAYERS

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Abstract
Handball in particular requires intermittent bouts of intensive physical activity, with defensive and offensive actions that include specific movements and the repeated explosive muscular contractions needed for sprinting, jumping, turning, changing pace, and ball throwing (Massuca et al. 2014).We hypothesized that: match performance would be more closely correlated with 1) HBCT scores than with scores for the nonspecific tests and 2) with RSA than with Yo-Yo-IR1-test scores.

Keywords: Handball, muscular strength, jumping performance, RSA test.

Introduction

Coaches and sports scientists need field performance tests of proven validity in order to regulate and enhance their handball training programs. Assessments of handball players have to date used general or specific tests of endurance, strength, jumping, sprinting tests, and throwing (Buchheit et al. 2012; Wagner et al. 2016).However, it remains unclear how far these various factors contribute to the description of inter-individual differences in actual match performance. Regular performance diagnostics are usually limited to functional tests (e.g., 30 m-sprint test, countermovement jump, squat jump test, vertical-jump test, abdominal strength, Yo-Yo- IR1-test; RSA test) (Dos et al. 2014; Krüger et al. 2014). In contrast, assessments rarely take account of handball specific skills (e.g., dribbling, throws, passing, catching the ball, feints). Recent investigations (Wagner et al. 2016; Spasic et al. 2015)have sought valid performance tests for team handball players, butlittle is yet known about relationships between field tests and match performance, in part because there has been no adequate method of summarizing actual match performance.
Thus, the aims of this study were (i) to develop an effective "gold standard" match performance score (mps), (ii) to use this score to validate various potential field tests, and (iii) to compare the validity of a handball specific complex test (HBCT) with two nonspecific tests (the Yo-Yo-IR1-test and the RSA test) in the evaluation of elite professional handball players.

Methodes

Participants
Thirteen male team-handball players from the premier German league (pivots, *n*=2; backs, *n*=8; wings, *n*=3) agreed to participate in the study. Four of the group were left-handed.

Testing Schedule
Handball-specific-complex-test (HBCT)
The HBCT (Schwesig et al. 2016) comprised a sequence of 4 activities: agility parcours, defensive actions, sprinting (10 m, 20 m), and throw-on-goal sequences. This sequence was completed twice, and included 5 active pauses (for 15 seconds, 4 times, and once for 30 s), thus simulating the intermittent nature of a handball match. Parameters measured under load included the number of technical errors, run times (e.g., 10 m sprint, 20 m sprint, best and whole time) and throwing velocity. The intra-rater reliability of each parameter of the HBCT has previously been reported by Schwesig et al. (2016).

The Yo-Yo Intermittent Recovery Test Level 1

The Yo-Yo-IR1-test was performed as outlined by Krustrup et al. (2003). Briefly, 20-m shuttle runs were performed at increasing velocities, with 10 s of active recovery (2 x 5 m of jogging) between runs until the participant was exhausted. Before testing, players completed a standardized warm up comprising 5 min of low-intensity running followed by the first 4 bouts of the test. The test itself was considered as completed if the participant twice failed to reach the finish line in time (objective evaluation) or felt unable to complete another shuttle at the dictated speed (subjective evaluation). The total distance covered during the Yo-Yo-IR1-test was considered as the test "score" (Castagna et al. 2006). The mean heart rate during the first 10 minutes of recovery following the Yo-Yo-IR1-test was measured and calculated (Yo-Yo heart rate R_0-R_{10}). The Yo-Yo-IR1-test is known to have a coefficient of variation (CV) of 3.6 % with an ICC of 0.94 (Krustrup et al. 2003).

Repeated-Sprint Ability

The RSA test was performed as outlined by Buchheit et al. (2008). Two sets of timing gates (Microgate Polifemo, Bolzano, Italy) were set up, working in opposite directions, so that participants could start the next run from the end at which they had finished the preceding sprint. Each sprint started 0.5 m behind the first timing gate, and the digital timer started automatically when the photo cell beam was broken. The test comprised six 30 m (15 + 15 m sprints with 180° turns, ~ 6 s) shuttle sprints that included acceleration and deceleration phases at the turning line, and 14 s passive recovery intervals. Three seconds before the start of each sprint, participants took up their starting position and awaited the starting signal (with a 3 s countdown). Strong verbal encouragement was given during all sprints, and participants were instructed to produce maximal effort throughout (i.e., to avoid pacing strategies). The best time in a single trial (RSA_{best}), the total time (RSA_{TT}) and the percentage decrement in performance (RSA_{dec}) were determined. The CV and ICC for the RSA test were 3.3% and 0.95, respectively.

Quantitation of match performance

A match performance score for field players was developed based on the prior work of Schwesig et al. (2016) it was calculated as follows:

mps = (field goals * shooting percentage/100 + assists + steals + blocks – technical mistakes – penalty score) / number of matches

The penalty score was calculated as:

penalty score = yellow card * 1 + two minutes time penalty * 3 + red card *5

The higher the calculated score, the better the match performance of the athlete.We excluded goalkeepers from our analysis, because the calculation for these players is different (the percentage of throws caught, based on the total numbers of throws).

Statistical Analyses

All statistical analyses were performed using SPSS version 22.0 for Windows (SPSS Inc., Chicago, IL, USA). Descriptive statistics (mean, standard deviation (SD), minimum, maximum, 95% confidence intervals (95% CI)) were ascertained for all variables. Validation of potential test items was performed using linear regression analysis (model: inclusion). The test parameters (e.g., run 1, distance, heart rate after first half, throwing velocity first throw) were considered as independent variables and the match performance score as the dependent variable. Items were considered as relevant if the explained variance of the independent variable relevant to the dependent variable was greater than 10% ($r^2 > 0.10$). Before linear regression analysis the residues were visual checked for normal distribution. We conducted this examination for all independent parameters in relation to mps using by a plot of normal distribution.

Results

A large volume of data was collected during matches in order to generate the mps. The number of matches played by individual subjects ranged from 13 to 32 (mean: 25). The data obtained for match performance parameters and the overall mps are presented in Table II. The mps, based on the 11 criteria shown, ranged from -0.06 (poorest match performance) to 3.98 (best match performance). Participation in at least 10 matches during the season 2015/2016 was a prerequisite for including an athlete in the analysis. Load (e.g. time, throwing velocity) and stress parameters (e.g., heart rate, lactate) of all tests (RSA test, YoY o IR1, HBCT) were collected and analyzed using by linear regression analysis. For example, the first run of the RSA test explained 11% of the variance in mps. The validity of all 48 parameters from the field tests was assessed in terms of linear regression relative to the match performance score.Nine of the 48 parameters that were evaluated explained more than 10% of the total variance:

- HBCT/throwing velocity second throw, round 1: r^2=0.37,
- HBCT/resting heart rate: r^2=0.18,
- HBCT/resting blood lactate: r^2=0.17,
- HBCT/recovery heart rate recovery minute 0 to minute 10: r^2=0.15,
- RSA test/heart rate recovery minute 10: r^2=0.15,
- RSA test/heart rate recovery minute 6: r^2=0.13,
- RSA test/run 1: r^2=0.11,
- RSA test/run 2: r^2=0.11,
- HBCT/heart rate recovery minute 10: r^2=0.10.

None of the Yo-Yo-IR1-test scores yielded a useful amount of explained variance (range 1 to 7%).In summary, the RSA test generated the largest number of relevant measures (RSA 27% (4/15);HBCT: 5/31, 16%; Yo-Yo-IR1-test: 0/6; 0%).

Table 1. Descriptive statistics (mean ± SD) and validity of individual test performance scores relative to the gold standard of match performance score (based on at least 10 matches during the 2015/2016 season; n=13), using linear regression analysis (model: inclusion). CI=confidence interval. Variables with anr^2>0.10 are highlighted in bold type.

Parameter	Mean± SD	Functionalequation	CI for m	r^2	p
HBCT – stress parameters					
Resting heart rate ($b*min^{-1}$)	68± 9.12	y=0.06*x – 2.62	-0.03 – 0.14	**0.18**	0.153
Heart rate after first half ($b*min^{-1}$)	180±8.47	y=-0.01*x – 0.79	-0.09 – 0.10	0.00	0.959
Heart rate before second half ($b*min^{-1}$)	180±8.47	y=-0.01*x +0.27	-0.08 – 0.09	0.00	0.890
Heart rate after second half ($b*min^{-1}$)	182±7.07	y=-0.02*x +4.79	-0.13 – 0.10	0.01	0.713
Heart rate recovery minute 2 ($b*min^{-1}$)	133±17.2	y=-0.01*x +2.18	-0.06 – 0.04	0.01	0.739
Heart rate recovery minute 6 ($b*min^{-1}$)	111±11.1	y=0.01*x +0.30	-0.07 – 0.08	0.01	0.810
Heart rate recovery minute 10 ($b*min^{-1}$)	108 ± 11.7	y=0.03*x – 2.45	-0.03 – 0.10	**0.10**	0.286
Resting lactate (mmol/l)	0.94±0.30	y=-1.72*x + 2.83	-4.24 – 0.80	**0.17**	0.161
Lactate recovery minute 2 ($mmol*L^{-1}$)	13.9±4.02	y=-0.02*x +1.43	-0.22 – 0.19	0.00	0.862
Lactate recovery minute 6 ($mmol*L^{-1}$)	14.3±3.56	y=0.02*x +0.89	-0.21 – 0.25	0.00	0.834
Lactate recovery minute 10 ($mmol*L^{-1}$)	13.3±3.81	y=0.03*x +0.80	-0.18 – 0.24	0.01	0.758
Recovery heart rate (relative); end of first half-start of the second half 2 (%)	3.45±1.38	y=-0.06*x +1.41	-0.65 – 0.53	0.00	0.829
Recovery heart rate (relative); recovery minute 0 to recovery minute 10 (%)	41.0±5.42	y=-0.09*x + 4.82	-0.23 – 0.05	**0.15**	0.190
Recovery lactate (relative); recovery minute 2 to recovery minute 10 (%)	10.3±8.78	y=-0.02*x +1.40	-0.11 – 0.07	0.02	0.658

Discussion

To date, there is no comparable handball-specific match performance score (mps) in the scientific literature, with the exception of a preliminary version of the present test used in an earlier evaluation of the HBCT (Schwesig et al. 2016).In the light of this earlier experience, we modified the equation for determining mps in order to maximize its relationship with HBCT scores.The main finding from the present study is that HBCT and RSA test scores have a much greater predictive value than data obtained from the Yo-Yo-IR1-test.It seems that speed and the ability to recover functional capacity are particularly relevant to the performance of elite handball players.Nevertheless, only 4 of the HBCT stress parameters explained more than 10% of the variance in match performance. The relatively large proportion of explained variance (r^2) for “throwing velocity, second throw” in round 1 (0.37) is out of line with that for other throwing velocity values (0.01 to 0.05), and this finding should not be over interpreted pending its replication.

In comparison with our earlier investigation of the HBCT (Schwesig et al. 2016), we found a larger number of valid parameters (five vs. two), but in line with our previous study, valid measures were all physiological stress parameters related to the recovery process, with the exception of the throwing velocity for the second throw, round 1. The larger number of valid parameters in the present study may reflect an improved assessment of match performance. Nevertheless, further effort is needed to perfect the "gold standard" of match performance. There has been only one similar study previously (Wagner et al. 2016). Wagner et al (2016) evaluated their measures against a match-based handball performance test (total distance covered). With an inter-test interval of seven days (n=17), they found an ICC > 0.70 for the peak blood lactate concentration, HR and ball velocity, and a high correlation between these measures and their assessment of game performance.

The complexity of match performance unfortunately limits the usefulness of a simple functional parameter such as "running distance." Souhail et al. (2010) investigated the direct validity of the Yo-Yo Intermittent Recovery Test (Level 1) relative to match performance in 18 adolescent handball players (14.3±0.5 years). Yo-Yo-IR1 performance (1.831±373 m) was significantly and fairly closely related (r=0.88, p<0.01) to total game distance (1.921±325 m). This example illustrates a fundamental problem of previous research. Despite unanimous characterization of handball as a very complex team sport (e.g., jogging, sprinting, backwards movement, sideways movement, jumps, throws, steals blocks, changes of direction, one-on-one-situations, feints), match performance has previously been reduced to a few simple parameters such as total game distance or relative running speed. It is not surprising that such measures correlate highly with Yo-Yo test scores; the closeness of the relationship is no proof of test validity, since neither Yo-Yo-IR1-test scores nor the characterization of match performance in terms of distance and speed reflect all the demands of handball.

Based on the parameter “throw rate”, Krüger et al. (2014) showed that differences specific to playing position increased with complexity of the test task. They found mean throwing velocities of 72.7 to 90.7 km*h^{-1}, depending on the type of throw and the playing position, but their overall values were comparable with the range found in our study (73.2 to 87.3 km*h^{-1}). According to the test design and instructions to athletes, the highest throw velocity was seen in the first throw of round 1 (87.3 km*h^{-1}) and on average the lowest value was noted in the last attempt of round 2 (73.2 km*h^{-1}).Schwesig et al. (2017) previously developed and validated an ice-hockey specific complex test (IHCT) and an ice hockey specific match performance score (mps). They found closer relationships between mps and nonspecific off-ice and IHCT tests than those found in the present investigation (e.g., postural stability: r^2=0.39; cerebral postural system: r^2=0.35, maximal relative squat: r^2=0.37) and IHCT weave agility with puck score: r^2=0.39).

The perfection and validation of the match performance test remains an essential first step in further evaluating other potential test procedures (Schwesig et al. 2016).Validity of the mps could be assessed, for instance, in terms of its ability to predict the relative performance of various handball teams over a competitive season. Match performance is itself a multifactorial construct and the challenge is to measure all relevant individual components (offensive action: goals, assists, one-on-one balance; defensive actions: steals, blocks, one-on-one balance, penalties) and then to combine such data into an appropriately weighted overall performance score.

This is the first study to develop and use a match performance score for a team of male professional handball players, based on observations made over an entire season of play. Although there is scope for further refinement of the match performance test, the present results underline the low validity of the RSA test and HBCT in assessing handball players. There seems little scientific basis for performance diagnostics based on procedures such as the RSA, Yo-Yo-IR1-test, sprint or jump tests). The current MPS better reflects the complexity of handball relative to the procedure used in an earlier validity study (Schwesig et al. 2016), but further research is needed to perfect match assessments on and off the field.

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VERIFICATION OF ACCURACY OF DISTANCE COVERED MEASUREMENT BY NEW TIME-MOTION ANALYSIS SYSTEM SAGE ANALYTICS

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Abstract: SAGE Analytics is newly developed real-time locating system based on radio waves technology and filled in MEM's sensors and heart rate sensors. This study assessed the measurement error of distance covered of the players with and without data filtering from SAGE Analytics. Ten players were instructed to walk five times (200 attempts) marked distance of 12 m, 18 m, 25 m, and 30 m with the sensor placed between scapulars. The distance covered was evaluated as raw data (without any filter) and filtered data. The Standard error of measurement and Pearson product-moment correlation due to homoscedasticity were calculated. The distance covered gained with filter was 20.23 ± 7.67 m and without filter was 20.92 ± 7.61 m. The difference between real distance and filtered data distance was 0.32 m and 1.05 m of raw data. The Standard error of measurement of filtered data was 1.15 m and 1.46 m for raw data. Pearson product-moment correlation was r=0.98. The results showed that the measurement error of the SAGE Analytics is acceptable and comparable with other time–motion analysis systems, but the attention to construct and to verify data filters is grossly important to get accurate data.

Keywords: Time-motion analysis, handball, load

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Introduction

The sport games are sports with intermittent nature due to the changing situational conditions and number of intervening variables characterized by irregular changes in very short time periods (up to 10 sec) between high intensity and low intensity which are connected to recovery processes (Abdelkrim, El Fazaa & El Ati, 2007; Hulka, Cuberek 2014).

Contemporary training process underwent lot of shifts based on increasing scientific and expert knowledge about the nature of conditioning in court and field sports. The specificity of the physical training become the key factor, when planning the training process because of attaining of 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 a player's load intensity and activities during a training process.

Just only the correct modelling of these match conditions in a training process enables specific adaptations and optimizes the improvement of individual players as well as teams as a whole (Spencer, Bishop, Dawson, & Goodman, 2005). It is therefore essential to obtain detailed knowledge of players' loads during a match, as this knowledge enables trainers to adequately model the load intensity and the type of activities in a training process (Hůlka & Stejskal, 2005). Many systems are used to track the players load in outdoor sports games (Hulka, Cuberek 2014), but few information exists about indoor sports games.

Since the 1960s, different methods and techniques for assessing the external and internal load on players during a match have been used. The cartographical method was the first technique (technology) used for time-motion analysis (Carling, Bloomfield, Nelson, & Reilly, 2008). In this process, the player's movement was monitored relative to a coordinate map of the court, and the length of the movement trajectory, or the distance reached, was then computed. Subsequently, Spencer et al. (2004) and Reilly (2001) started to use the audio recording method for the same purpose. Although these techniques had some utility, both methods were based on a subjective visual prediction of the intensity and load of activities and assessment of the type of each physical activity (Psotta, 2003). At present, there are a vast number of much more objective techniques in use. In particular, current technology has allowed for the development of a number of techniques, which can be divided into four basic categories:

- *Innovative cartographical techniques* – A player's position is recorded by an electronic pen on an electronic tablet during the real time of a match.
- *Techniques based on radio waves* – A player's movement on the court is derived from information about his distance covered relative to a few defined stationary points (using radio wave receivers) with exact positions on the edge of the court. The player's true position is then defined by triangulation of these findings.
- *Techniques based on a Global Positioning System (GPS)* – After calibrating the court (using a GPS), software transfers global information about a player's position on the ground (in time) into a position on the court.
- *Techniques based on transferring a player's position from a digital video record into a coordinate system* – The player is automatically detected through the use of a color representation depicting the temperature differences between the players and the court. His position is then transferred into a coordinate system.

To interpret the data in a relevant fashion, the software must be evaluated for reliability, and possible measurement errors must be assessed. Based on the types of techniques and technology this software uses, we expect the following measurement errors to appear: 1. The comparison of the standard error of measurement of raw data and filtered data, 2. Homoscedasticity o measurement. This study assessed the measurement error of distance covered of the players with and without data filtering from SAGE Analytics.

Methods

Participants

Ten players (age = 17.25 ± 1.12 years; BMI = 23.1 ± 1.66 kg·m^{-2}) underwent the measurement. The players participate on five practices and one match per week. 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

The participants were instructed to walk five times (200 attempts) marked distance (line) of 12 m, 18 m, 25 m, and 30 m with the sensor placed between scapulars. The distance covered was evaluated as raw data (without any filter) and filtered data. The SAGE Analytics real-time locating system based on radio waves technology and filled in MEM's sensors was applied. All measurements took the place in handball indoor court with standardized size of the ice hockey court (40x20 m). The used filter of raw data calculated with two constants: only moves higher than 0.25 m were considered and the distance covered by higher speed than 20 m·s^{-1} were not considered. Moreover, the whole time of measurement was divided to 30 interval and ever interval was regarded individually.

Statistical analyses

Software Statistica 13 (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 Standard error of measurement (SEM) was calculated to interpret the size of error. To calculate the SEM, the following formula was used (Thomas, Nelson, & Silverman, 2005): SEM = SD*√(1-ICC), where SD is the sample standard deviation and ICC is the calculated intra-class correlation coefficient (unbiased error), the $ICC=(MSS - MSE) \cdot MS^{-1}$, where *MSS* is the mean square of the subjects, *MSE* is the mean square of the error, and *MS* is the mean square. The coefficient of variation (*CV*) was calculated as a percentage expression of typical error of measurement (*TEM*) according to Hopkins et al. (2001). The homoscedasticity was assessed using the Pearson product moment correlation coefficient (the absolute difference between two repeated assessments vs. the mean of the two repeated assessments). The statistical significances of all parts of the analysis were determined at an alpha level of $P < 0.05$.

Results

The distance covered gained with the filter was 20.23 ± 7.67 m and without the filter was 20.92 ± 7.61 m. The difference between real distance and filtered data distance was 0.32 m and +1.05 m of raw data. The CV was calculated as 1.61 % for filtered data and 5.16 %. The Standard error of measurement of filtered data was 1.15 m and 1.46 m for raw data. Pearson product-moment correlation was r=0.98.

Discussion

This study assessed the measurement error of distance covered of the players with and without data filtering from SAGE Analytics.

The ProZone technology, based on the transfer players' position into a digital video record coordinate system, presented limits of agreement during 30 m sprint measurement with means of approximately ± 0.12-0.85 m (Di Salvo, Collins, McNeill, & Cardinale, 2006). Reinhold and De Boer (2008) analyzing the system Inmotio 3D Soccer (based on radio wave technology), found its lower absolute bias to be ± 0.05 m. The CV was calculated as 1.61 % for filtered data and 5.16 %. Due to the long distances measured during games, we consider this value of SEM and CV to be highly sufficient. The observed value of the standard error of measurement of 0.34 m indicates the satisfactory quality of this instrument. This value appears to be insignificant in view of the purpose of the SAGE system with filtered data, player's intermittent load should be assessed based on the distance covered during the match, training or other occasions. It cannot be expected that acceptance of such an error would represent a meaningful risk in or the wrong individualisation of the training process for specific players' posts. The results of correlation analysis showed homoscedasticity of measurement, thus the error of measurement should not increase with growing distance covered of the players.

Limits of Study. The main limitation of our analysis was the relatively short duration of the observed periods. Other potential limitations include the selection and relatively low number of observers.

Conclusion

The results showed that the measurement error of the SAGE Analytics is acceptable and comparable with other time–motion analysis systems, but the attention to construct and to verify data filters is grossly important to get accurate data.

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A FUNDAMENTAL STUDY ON THE DEVELOPMENT OF A SIMPLISTIC "COURT SHUTTLE TEST" DESIGNED FOR HANDBALL PLAYERS

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Summary
The objective of this study was to develop a simplistic "Court Shuttle Test" designed for handball players. We aim to create a new running test to be included as part of a training schedule, which can be used to assess the physical strength of players and can be completed in a small 40 m court. While the Coat Shuttle Test (CST) is an exercise in which high intensity anaerobic exercise is repeated, from the results of the second time the possibility of it also becoming a new field test able to evaluate aerobic ability is shown.

Keywords: handball, physical training, Court Shuttle Test

Introduction
Due to its competitive nature, handball is called "the game of transition," because of the rapid alternation between offensive and defensive play as well as the intermittent running and sprinting performed by the players. According to Bilge[1], a handball training program should be structured in accordance with the characteristics of a ball game and should take into account the duration of the game, heart rates, the amount of exercise, type of running, running distance, and even the characteristics of each position. Interval training has been reported as the most effective method for athletic performance. Moriguchi et al.[2] developed an intermittent training program that incorporated change-of-direction sprints, with muscle activity and throwing motion interspersed with recovery periods; this was reportedly associated with the ability to generate anaerobic energy. Furthermore, aiming to improve high-intensity running capacity and repeated sprint performance in junior handball players, Buchheit [3] verified the effectiveness of handball-specific high-intensity training by including an exercise in which the ball was passed between two players while running at a set speed, as well as 4 vs. 4 handball games. These studies emphasized the importance of the ability to continuously generate anaerobic energy in handball. In an actual training setting, it is important to efficiently and continuously assess handball-specific indices of physical fitness. However, the evaluation and development of aerobic and intermittent exercise capacity are influenced by staff- and setting-related issues, with many obstacles to maintaining player motivation. The objective of this study was to develop a simple "Court Shuttle Test" for handball players. We aimed to develop a new running test for inclusion in a training schedule, which can be used to assess physical fitness and can be performed in a 40-m court.

Methods
Subjects:
First, we examined how the Japan women's national handball team (n=21) incorporated the "Court Shuttle Test" into a training program. Twenty-five top female college (FU) handball players in the Kyushu Regional Top Student Handball League underwent a series of field tests from April to June 2016. Mean age, height, and weight were 19.5 ± 1.2 y, 160.79 ± 4.22 cm, and 56.43 ± 6.67 kg, respectively (presented as mean ± standard deviation [SD]). Written explanations of the purpose, measurement items, and measurement methods were distributed to all participants, and consent was obtained. Consent was also obtained for the use of individual measurement data.

Measurement parameters :

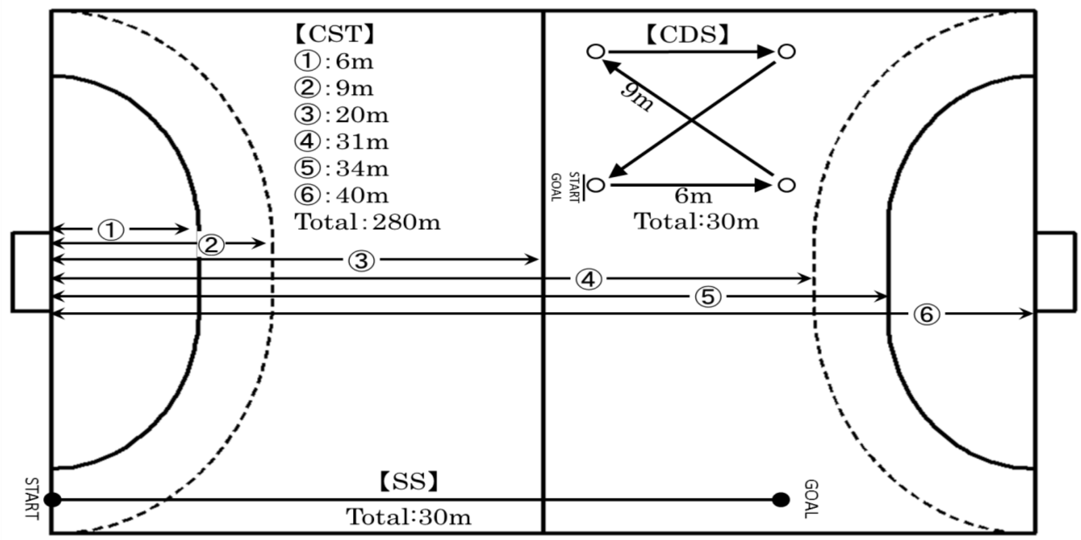
The following parameters were measured: Court Shuttle Test (CST), 30-m Straight Sprint (SS), Change-of-Direction Sprint (CDS), Yo-Yo Intermittent Recovery Test Level 2 (IR2), and 12-min running test (12MR). The CST required the players to repeatedly run at full speed through 6 turns totaling 280 m on a 40-m court (1st time). After a 2-min rest, they repeated the process (2nd time) (Fig. 1). The CDS tests were started on the right, and all turn angles were approximately 130° (Fig. 2).

We also conducted the YYIR2 (Bangsbo et al. [4]) to assess intermittent exercise capacity and the 12MR (Cooper et al. [5]) to evaluate aerobic capacity.

Statistical analysis:

All data are shown as mean ± SD. The Pearson product-moment correlation coefficient was used to calculate the correlation between the results of the SS, CDS, YYIR2, CST, and 12MR. The unpaired t test was used to compare the results for national players (National) with those for university players (FU), and the paired t test was used to compare the 1st CST time with the 2nd CST time. Statistical significance of the test results was set at 5%.

Fig. 1 CST, 30-m SS, and 30-m CDS



Result and discussion

Mean CST time, the difference between 1st and 2nd CST times, and the rate of delay are shown in Table 1 and Fig. 2. In both 1st and 2nd CST times, the National team was significantly faster than the FU, by approximately 5 s. Therefore, the Japanese female handball players should be able to complete a 280-m CST in under a minute. However, the 2nd CST was significantly more delayed than the 1st CST (National team, 5.5 s; FU, 6.2 s). The rates of delay were 109.1% and 109.7% for the National team and FU, respectively. The difference was not significant. Despite the difference in the level of competition, the 2nd CST was only delayed by about 9-10% in both groups.

Table 1. CST Results

	National	FU	*N vs F
1st CST (s)	59.9±2.4	64.3±2.9	*p<0.01*
2nd CST (s)	65.5±4.1	70.6±4.3	*p<0.01*
Delay: 1st CST– 2nd CST (s)	+5.5±2.3	+6.2±3.2	*ns*
Rate of delay (%)	109.1±3.7	109.7±4.9	*ns*

*Unpaired t test

Fig. 2 Delay in CST

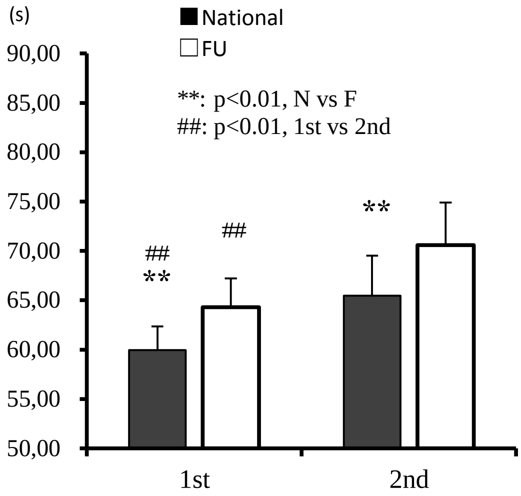


Table 2 shows the associations between measured parameters. A strong correlation between the 1st CST, YYIR2, and 12MR was observed. No correlation with SS was observed. The faster the completion time of the 1st CST, the lower the YYIR2 score; this strong correlation indicates that the 1st CST can predict anaerobic and intermittent exercise capacity (Fig. 3).

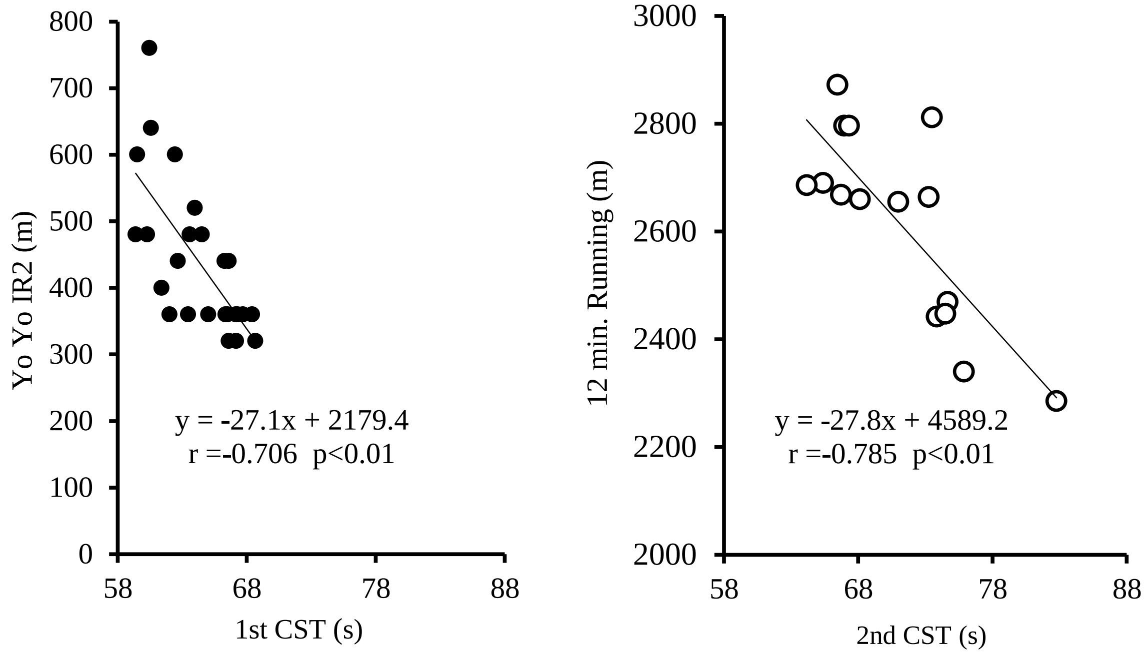
Table 2. Correlations between measured parameters

	30-m SS	YYIR2	1st CST	2nd CST	12MR
30-m SS		-0.291	0.145	0.194	0.091
YYIR2	-0.291		-0.706**	-0.685**	0.186
1st CST	0.145	-0.706**		0.664**	-0.625**
2nd CST	0.194	-0.685**	0.664**		-0.785**
12MR	0.091	0.186	-0.625**	-0.785**	

**p<0.01; Pearson product-moment correlation coefficient

Moriguchi et al.[3] demonstrated a significant positive correlation between the completion time for a 560-m intermittent CDS and that for a 400-m anaerobic running test. In these studies, the correlation between CDS and aerobic running capacity was not strong, possibly due to passive rest during intermittent running. The strong correlation between the 1st CST and the 12MR in this study may be attributed to the fact that the total running distance in the 1st CST, the turns (vigorous muscular activity), and the resting periods were not set. On the other hand, if we focus on the 2nd CST, the correlation with 12MR becomes very strong (Fig. 3), and the link with the YYIR2 is slightly weakened. These results indicate that the 1st CST, which is a 280-m CDS, demonstrates intermittent exercise capacity, and the 2nd CST, which was performed after a 2-min rest, can be used as a field test to evaluate aerobic capacity.

Fig. 3 Correlations between 1st CST and YYIR2 (left fig.), and between 2nd CST and 12MR (right fig.)



Laursen and Jenkins[6] defined High-intensity Interval Training (HIT) as training comprised of repeated exercise bouts for an appropriate duration (10 s to 5 min); HIT is more intensive than aerobic training, and the high-intensity exercise bouts are alternated with periods of lower-intensity exercise or rest. The CST that we conducted is consistent with HIT, which is known to increase muscle oxidative capacity and glycogen content, while reducing lactic acid production and improving peripheral vascular structure and function, as well as overall athletic performance[7]. The CST in handball is not only a field test, but should also be used in regular training. Therefore, further research focused on running distance and rest is necessary.

Conclusion

This study verified that CST interspersed with recovery periods can serve as a simple and effective field test for evaluation of handball-specific physical fitness. We established strong links between the 1st CST and intermittent exercise capacity as well as between the 2nd CST and aerobic capacity. This suggests that CST can also serve as a simple field test for evaluation of the ability to maintain handball-specific intermittent anaerobic capacity.

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FACTORS AFFECTING DECELERATION AND REACCELERATION IN HANDBALL PLAYERS: EFFECT OF CATCHING WHILE RUNNING ON CHANGE OF DIRECTION AND REACCELERATION

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Summary
To clarify whether catching movement immediately before a change of direction affects subsequent reacceleration in handball players, a field test investigation was performed. The subjects performed 2 types of 505 tests: a regular 505 test (CON), and a 505 test in which catching is performed midway during the sprint, and is called the Catch-a-Ball Test. It was determined that when the "catching" action is included in the change of direction during deceleration, the cognitive elements of the change of direction are disturbed, resulting in rapid deceleration. This generated a larger inertial force, which caused a delay in acceleration.

Keywords: handball, physical training, change of direction, 505 test

Introduction

The ability to change direction quickly is very important in handball. Movement speed is always changing, and the change is generated actively or passively, depending upon the game conditions. To achieve success in handball, the players must accurately execute a variety of separate movements while repeatedly changing speed from acceleration to deceleration. This type of ability is known as coordination[1)], and it has been reported that training effect is at its peak during preadolescence when players are highly sensitive to skill development[2)]. Japanese junior handball trainers are aware of the importance of coordination training; although various drills are employed, there has been little research on the evaluation of agility skills. We feel that analyzing the factors that comprise agility skills is important to improve performance in Japanese handball players.
Sprinting power, leg muscle strength, skill, alertness, etc., are intricately involved in the ability of sports players to change direction[3)]. Young[3)] showed that leg muscle qualities, straight sprinting speed, and technique are involved in the speed of direction change, but also demonstrated the parallel effect of perceptual and decision-making factors. In reality, it is impossible to subdivide these factors, which affect deceleration and acceleration for all direction changes during a game. Various features specific to handball have a significant effect on change in speed, but no reports have clarified these details. We hypothesized that cognitive factors may significantly affect the ability of a player to change direction during a handball game, and used a new field test to examine this premise.
To clarify whether catching movement immediately before a change of direction affects subsequent reacceleration in handball, a field test investigation was performed.

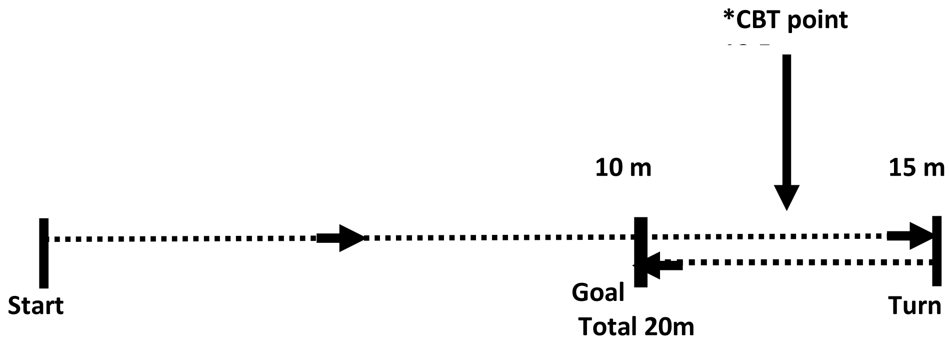
Method

Subjects:
The subjects were 33 elite handball players (18 males and 15 female) of the National university championship level in the change-of-direction sprint test. This group included 3 U19 players who had represented Japan in competition. Their daily practice consisted of 1 hour of physical training

(stretching, coordination, sprinting, jumping, and plyometric and resistance training) 6 times per week, before and after ball exercises.
All experiments were conducted in the handball courts at Fukuoka University, and measurements were taken from January to April 2016. We fully explained the aims and methods of the experiment to the subjects and obtained consent.

Physical measurements and 505 tests:
The following four measurements were obtained: straight sprint test (30 m), two change-of-direction sprint tests (2 types of 505 tests), and the standing long jump. The 505 test consists of a 15-m straight line sprint and a 180° change of direction, followed by a 5-m straight line sprint (Fig. 1). The 5-m straight line sprint immediately before the change of direction was defined as the Deceleration and the 5-m straight line sprint after the change of direction as the Reaccelerating section. The subjects performed 2 types of 505 tests: a regular 505 test (CON), and a 505 test in which catching is performed midway during the sprint, and is called the Catch-a-Ball Test (CBT). In the CBT, subjects caught a thrown ball in the empty space at the 12.5-m point in the Decelerating section (CBT point), immediately prior to the change of direction.

Fig. 1 Two types of 505 tests.



*Ball catching point (12.5 m) during the sprint.

Statistical analysis:
All data obtained are shown as mean ± SD. The paired t test was used to compare the results of the CON and CBT. The Pearson product-moment correlation coefficient was used to calculate the correlation between the results of the 505 test total times, the Decelerating section time, and the Accelerating section time. Statistical significance was set at 5%.

Result and discussion

The results of the 505 tests are shown in Table 1. There was no significant difference between CON and CBT in the sprint time at the 10-m point for both males and females. At the 15-m direction change point, the time was faster for both males and females under CBT conditions, but there was no statistically significant difference in the males. However, at the 20-m goal point, both males and females had a slower total time under CBT conditions than under CON conditions

Table 1. Two types of 505 tests: elapsed time at each point (s)

		10 m	15 m	20 m
Male players	CON	1.75±0.08	2.64±0.09	4.03±0.16
	CBT	1.75±0.07	2.61±0.09	4.14±0.17
	*CON vs CBT	*ns*	*ns*	*p<0.01*
Female players	CON	2.01±0.07	3.05±0.11	4.53±0.15
	CBT	1.99±0.09	2.97±0.11	4.55±0.18
	*CON vs CBT	*ns*	*p<0.01*	*ns*

*Paired T test

Table 2 shows the elapsed times in the 5-m decelerating section and 5-m reaccelerating section. The decelerating section was at 10-15, and the reaccelerating section at 15-20 m. We calculated the ratio of the reaccelerating to the decelerating section (A/D ratio). The results showed that the CBT time was faster in the 5-m decelerating section, with rapid deceleration compared to the CON. These differences were greater in female players. Furthermore, the time in the reaccelerating section was significantly slower under CBT conditions for both males and females, with a delay rate approximately 20% greater than the CON A/D ratio.

Table 2. Comparison between the Decelerating and Reaccelerating sections at 5 m

		Deceleration section 5-m (s)	Reacceleration Section 5-m (s)	A/D Ratio
Male players	CON	0.89±0.05	1.38±0.12	1.57
	CBT	0.87±0.05	1.53±0.12	1.78
	*CON vs CBT	*ns*	$p<0.01$	$p<0.01$
Female players	CON	1.04±0.07	1.49±0.09	1.44
	CBT	0.98±0.04	1.59±0.11	1.63
	*CON vs CBT	$p<0.01$	$p<0.01$	$p<0.01$

*Paired T test

These results suggested that when “catching” action is included in the change of direction in the Decelerating section, cognitive elements (deceleration plan, predictive movement, etc.) of the change of direction are disturbed, resulting in rapid deceleration. This generated a larger inertial force, which caused a delay in the Acceleration section.

Data supporting these findings are shown in Fig. 2 and 3. Fig. 2 shows the relationship between the initial acceleration section time (0-10) and the reaccelerating section time (15-20 m) after the direction change in each test. In the CON test (left) there was a strong correlation between the two acceleration sections, while in the CBT test (right) the correlation was slightly weaker. As a result, the decelerating section, which is preparatory for direction change, generates an unbalanced running action, which is thought to have resulted in delayed direction change.

Fig. 2 Relationship between Acceleration (0-10 m) and Reaccelerating section times (15-20 m), N=33

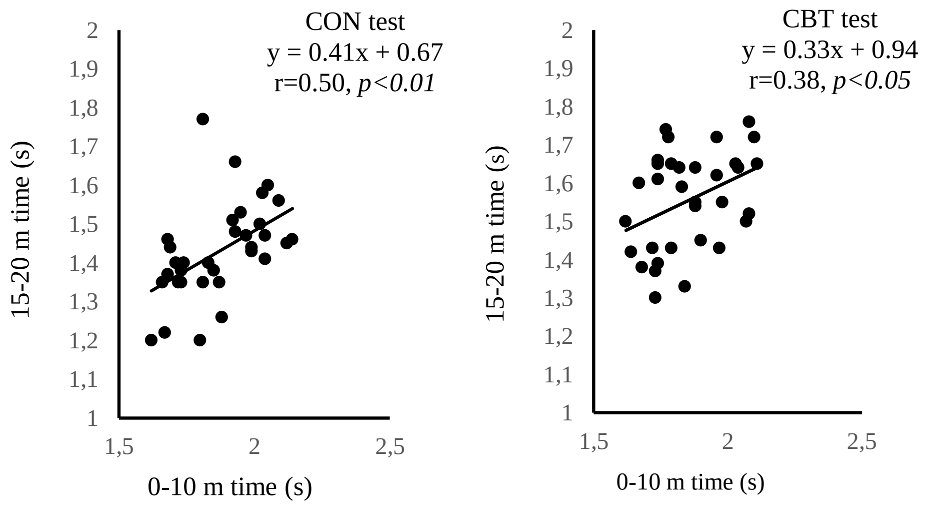


Fig. 3 Amount of change (δ) in sprinting time in the CON vs. CBT tests, N=33

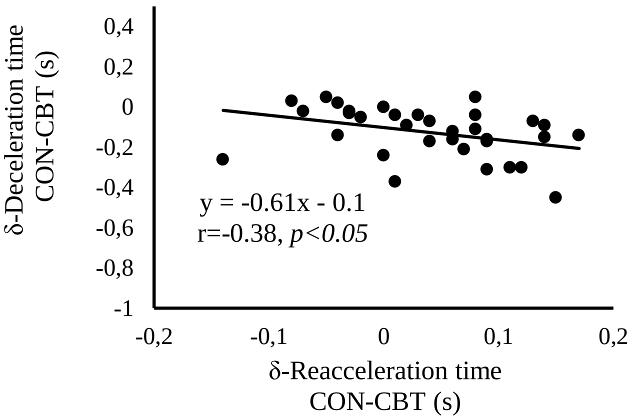


Fig. 3 shows the amount of change (δ) in sprinting time in the CON vs. CBT tests in the decelerating and reaccelerating sections. A significant negative correlation was seen when the disturbance of catching the ball was enough to shorten the decelerating section time and lengthen the subsequent reaccelerating section. Adding the action of catching the ball in front of the player to the exercise of simply running generates a disturbance in the player's braking mechanism; we predicted that efficient movement at the center of gravity would become difficult. The shortening of the decelerating section is thought to reflect delayed braking due to the catching action. It has been shown that when ball players change direction, they attempt to maintain stability by maintaining a low center of gravity, and the preparation for this action begins during running prior to the change of direction5). In CBT, the ball-catching action during deceleration destabilizes the deceleration plan and also destabilizes the center of gravity, which suggests that ball catching strongly affects the outward movement of the center of gravity upon change of direction.

Conclusion

This study investigated the effect of additional ball-catching action on the ability of handball players to change direction in the decelerating section of the 505 test. The results showed that in the CBT test, the decelerating section time shortened, while the reaccelerating section time lengthened. Ball catching during deceleration was shown to destabilize the deceleration plan as well as the center of gravity, thereby affecting the ability to change direction. It may be possible to strengthen the ability to change direction, which is uniquely necessary for handball, by devising various practical stressors during running (substantial, visual, judgmental, etc.), thereby separating the many decision factors that comprise the ability to change direction.

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COMPARISON OF THE EFFECTS OF DIFFERENT RESISTANCE TRAINING TYPES ON CHANGES IN UPPER-LIMB POWER OF HANDBALL PLAYERS DURING THE STARTING PERIOD

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Keywords: handball, strength training, plyometric training, flight speed of thrown ball

Abstract
According to many researchers, the flight speed of a thrown ball is considered to be a key ability determining the effectiveness of a player's game in the offense. The presented research was focused on the comparison of the influence of two types of resistance training used during the starting period on the speed of a thrown ball. The first training type was focused on developing maximum strength and power at the gym, while the second was based on dynamic exercises using medicine balls. Flight speed measurements of the thrown ball were conducted using a specialized radar at the beginning and the end of the first round of the game. The flight speed of the ball was measured during a stand throw, a leaning back throw and a jump throw. In the group implementing the plyometric training plan, slight increases in ball flight speed were noted. Among them, there was a statistically significant increase in the ball flight speed throw from the stand position, and it equalled 0.8 km/h on average. In the group carrying out resistance training, there was a slight statistically significant decrease in ball flight speed performed a leaning back throw, which amounted to 2.9 km/h.

Introduction
From the point of view of starting loads, handball is a very dynamic discipline in which short actions not exceeding 10-20 seconds tend to dominate. Over the course of the competition, there are repeated efforts performed at high intensity and of varying duration, which result in approximately 30-35% of the playing time to be in the anaerobic zone. The used technique (passes, throws, jumps, starts, changes in running direction) require the player to develop very high power in a short period of time. This makes the effectiveness of the technique largely dependent on the anaerobic power level of the athlete (Czerwiński 2001, Norkowski 2002, Thorlund et al. 2008).
Several researchers have highlighted the large influence of a player's ability to impart high speed to the ball during a throw on the efficiency of an athlete's offensive performance (Pauwels 1978, Jöris 1985, Eliasz et al. 1990, 1993, Bayios et al. 2001, Noffal 2003, Van den Tillar and Ettema 2004, Zapartidis et al. 2007, 2009, Andrade et al. 2010, Pontaga and Zidens 2012, 2014, Andrade et al. 2016). Therefore, it is not surprising that for many years, this ability has been the subject of many publications. These studies mainly concerned the relationship between the speed of the thrown ball and somatic features, the level of motor ability and the strength of athletes' individual muscle groups, as well as the biomechanical parameters of the throw (Pauwels 1978, Jöris 1985, Eliasz et al. 1990, 1993, Bayios et al. 2001, Noffal 2003, Van den Tillar and Ettema 2004, Zapartidis et al. 2007, 2009, Andrade et al. 2010, Pontaga and Zidens 2012, 2014, Andrade et al. 2016) Research shows that the strongest is a leaning back throw, and the best players are able impart a speed of about 100 km/h to the ball. The athletes characterized by the largest throwing power are backcourt players (Filliard 1985, Eliasz et al. 1990, 1993, Hermassi et al. 2015, Andrade et al. 2016). From the point of view of somatic structure, the greatest influence on the speed of the thrown ball is related to the range of the fingers and the length of the hand (Eliasz et al. 1993). The correlation of body-size features (body height, upper-limb length, trunk length, etc.) with the speed of the thrown ball was shown only in teenage groups, with a tendency to gradually decrease over time (Pauwels 1978).

Many publications emphasize the high dependence between muscle strength of the internal shoulder rotators and the force of the throw (Bayios et al. 2001, Noffal 2003, Zapartidis et al. 2007, Andrade et al. 2010, Pontaga and Zidens 2014, Andrade et al. 2016). Other works also indicate the correlation of throw velocity with: muscle strength of the elbow-joint rectifiers, range of rotation in the shoulder-joints (Van den Tillaar and Ettema 2004) and trunk rotation as well as pelvic movement (Wagner et al. 2010, 2011). Marques et al. (2007) and Debanne and Laffaye (2011) have also demonstrated the correlation between the results of the bench press and throw speed.
Another area of interest for researchers was the impact of different types of training methods and loads on increasing throwing speed (Goluch and Komor 1978, Van Muijen et al. 1991, Saeterbakken et al. 2011, Van den Tillaar and Marques 2011, Genevois et al. 2011). Some of the works were devoted to weight-training, but their results differed considerably from one another. Mikkelsen and Olsen (1976) and Goluch and Komor (1978) confirm the effectiveness of weight-training. In contrast to them, there are studies rejecting the positive effect of such training, while pointing to the beneficial effects of using balls of reduced mass (Van Muijen et al. 1991, Van den Tillar 2004). In addition, other publications have shown the positive effects of performing two-handed throws with a 3 kg ball (Hermassi et al. 2015) and bench press exercises leading to increased ball flight speed. As Debanne and Laffaye (2013) stated, the low coherence of the research results on this issue means that among trainers and researchers, there is no unanimity regarding the design of training programmes that would favourably increase the speed of the thrown ball.
The main aim of this study is to compare the effects of two resistance training types (plyometric and strength training) used during the preparatory phase on the ability to impart high speed to the ball during a goal shot. The tests were also designed to show whether advanced players were able to increase throwing speed by means of resistance training during the starting period

Material and Methods

Description of the study group

The group consisted of 28 handball players, representing three sports clubs participating in the first and second national Polish league competitions. They were all adults and had many years of training experience. After consulting the coaches, it was found that the workouts were similar in all of the clubs regarding volume and intensity and the used training methods. In addition, the athletes took part in additional training sessions conducted within the framework of this experiment.

Research organization

The study was conducted during the starting period (1st round of competitions) of the 2014/2015 season - from the beginning of September 2014 to the end of December 2014.
The participants were divided into 3 groups: group 1 - performing additional strength training (8 persons), group 2 - performing additional plyometric training (8 persons), group 3 – undergoing standard training (12 persons).

Table 1. Description of the study groups

	Group size	Body height [cm]	Age [years]	Training experience [years]	Body mass 1 [kg]	Body mass 2 [kg]
Group 1 (strength training)	8	183.1 ± 4.18	23.1 ± 2.53	9.9 ± 3.18	86.04	86.25
Group 2 (plyometric training)	8	183 ± 5.94	21.1 ± 2.17	10.4 ± 1.92	88.69	87.24
Group 3 (standard training)	12	182.7 ± 5.75	23 ± 3.05	11.2 ± 2.59	88.73	88.86

Body mass 1 – body mass at the beginning of the starting period

Body mass 2 – body mass at the end of the starting period

The group undergoing additional strength training was composed of athletes who volunteered to perform additional training at the gym. The group subjected to extra plyometric training was composed of athletes from one of the clubs who additionally implemented the plyometric training plan. The standard training group consisted of competitors who did not participate in additional training sessions.
Measurements were conducted twice. The first measurement series was performed at the beginning of the first round, and the second at its end.

The experiment
The studied athletes were divided into 3 groups, two subjected to additional power-oriented training and one to standard training.
The first group performed two additional units of strength training lasting about 45 minutes each. One training type was focused on developing maximal force, while the other concentrated on the development of muscle power. In the training type aimed at shaping maximal force, the following exercises developing the muscles of the upper limbs and the trunk were implemented: the deadlift, the shoulder press and the bench press. The weight was chosen so that the practitioner could perform 3 to 6 repetitions of the exercise in 3-4 series. In the training type aimed at developing maximal power, the following exercises shaping the muscles of the upper limbs and trunk were used: the clean, the push press and dynamic bench press. The number of series ranged from 3 to 4, and 3 to 6 repetitions were performed in each series.
The second group performed about 30-40 minutes of plyometric training twice a week. Plyometric training of the upper limbs and the trunk was based on various types of two-handed medicine ball throws. The number of series varied between 3 to 4, while the number of throws in the series ranged from 6 to 12.
Group three consisted of athletes who only participated in club training sessions.

Scope of research.
The study included measurements of the flight speed of a ball thrown towards the goal using three kinds of throws: stand throw, leaning back throw and jump throw. Measurements were carried out using a specialized radar. Each type of throw was measured three times. The best speed out of the three was taken into account.

Statistical analysis
The average arithmetic mean for the subjects was determined to illustrate the participants' level of studied parameters. In order to determine the significance of changes in the level of the tested parameters, the Student's *t*-test was used. ANOVA was used to determine the significance of differences in the mean values of the analysed parameters. In order to better illustrate the dynamics of ball flight velocity changes, the percentage increase rate was calculated according to the following formula:
$W_{\%} = ((X_K - X_P) / X_k) \times 100\%$
(Xk - the final value of the tested parameter, Xp - the baseline value of the tested parameter).

Results
During the preparatory period, among the three groups tested, only the group performing additional plyometric training recorded increases in the velocity of the thrown ball. Increases in the speed of the ball thrown from a standing position were 0.8 km/h on average and turned out to be statistically significant. A slight decrease in this capacity was noted in the group performing the additional strength training plan. The largest decrease was found in the case of the leaning back throw, which was 2.9 km/h on average and proved to be statistically significant. The largest decreases, ranging from 4.6 km/h to 5.7 km/h on average, were observed in the group not subjected to any additional resistance training. In this group, the decrease in average speed for each kind of throw was statistically significant.

Table 2. Numerical characteristics of the studied variables and the size of their changes in value during the starting period

	Group 1			Group 2			Group 3		
	P I	***P II***	Δ_I	***P I***	***P II***	Δ_{II}	***P I***	***P II***	Δ_{III}
Stand throw [km/h]	85.4	84.0	-1.4	86.6	87.4	0.8*	82.2	77.5	-4.7*
Leaning back throw [km/h]	91.7	88.9	-2.9*	89.8	91.2	1.4	97.2	82.5	-4.6*
Jump throw [km/h]	87.0	85.1	-1.9	88.8	89.6	0.8	84.3	78.5	-5.7**

* statistically significant ($p< 0.05$)

** statistically significant ($p< 0.001$)

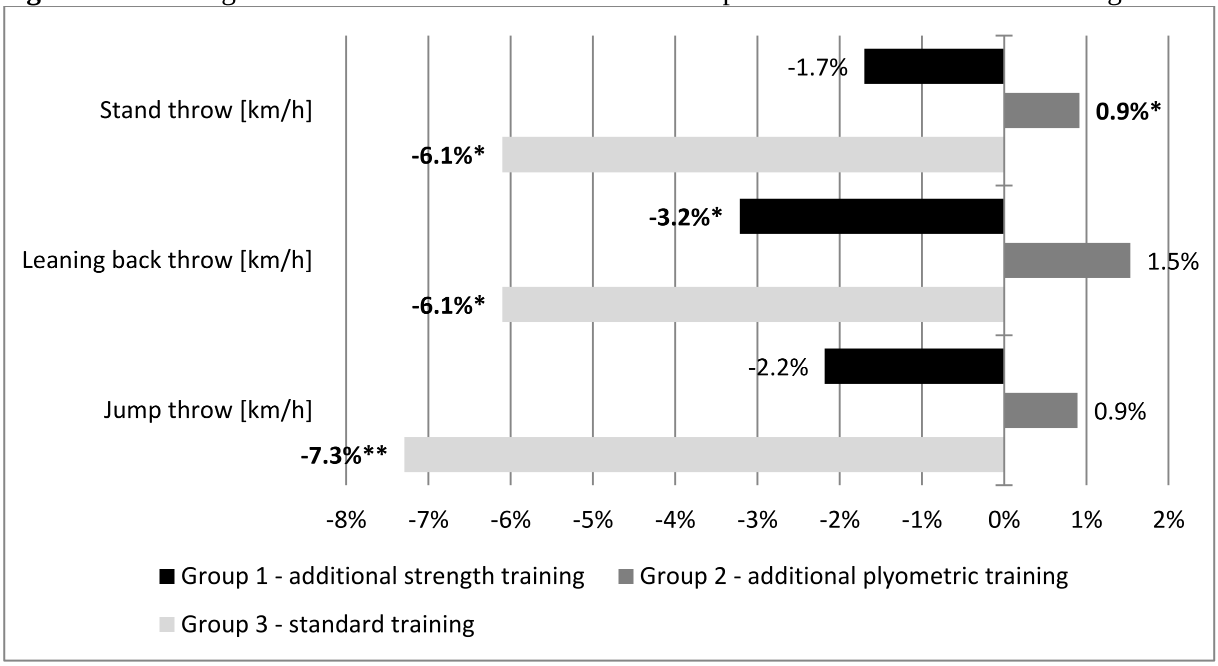
Δ_I – difference in group 1 arithmetic means (increase or regression between the 1st and 2nd test)
Δ_{II} – difference in group 2 arithmetic means (increase or regression between the 1st and 2nd test)
Δ_{III} – difference in group 3 arithmetic means (increase or regression between the 1st and 2nd test)

Differences in the flight speed changes of the thrown ball between the groups performing the extra strength and plyometric training plans were: 2.2 km/h in the case of the stand throw, 4.3 km/h for the leaning back throw and 2.7 km/h regarding the jump throw. However, none of these differences were statistically significant.

Table 3. Differences regarding increases in the studied variables for Group 2 compared to Group 1

		Group 2
Group 1	**Stand throw [km/h]**	2.2
	Leaning back throw [km/h]	4.3
	Jump throw [km/h]	2.7

Figure 1. Percentage indicators of the increase in the studied parameters and their statistical significance



* statistically significant ($p< 0.05$)
** statistically significant ($p< 0.001$)

Discussion

In various works, the ability to increase the speed of the ball in advanced players was questioned (Eliasz et al. 1990, Van den Tillar and Marques 2011, Genevois et al. 2014). In the above-mentioned publications, there were no statistically significant changes in the velocity of ball flight due to various physical exercises aimed at improving throwing force. In our own research, such changes have occurred, which may indicate the susceptibility of this ability to various types of training. This is confirmed by the results of Mikkelsen and Olesen 1976, Van Muijen et al. 1991, Van den Tillar 2004, Hermassi et al. 2015. In their research, they proved that training with balls of varied mass may significantly change the velocity of the thrown ball.

Above-the-head, single-handed throws are associated with extreme overburdening of the shoulder joints, which causes many athletes in throwing sports to sustain injuries and pain in their area (Dziak 2003, Kintzi 2003, Zazzali et al. 2011). The use of high-weight balls in this type of exercise adds to the burden placed on this joint. For these reasons and for the purposes of this work, the training plan abandoned single-handed throws with high-mass balls, replacing them with general two-handed throws. Such exercises significantly reduce shoulder-joint burden (Zazzali et al. 2011). The used exercises were successful in increasing ball flight speed, as similarly demonstrated in the study by Hermassi et al. (2015). Pauletto (1993) recommended similar exercises in his book on strength training in basketball, claiming that the combination of medicine-ball throw training combined with muscle strength training gives the best results in shaping the power of the upper limbs. He mainly proposed exercises performed using both hands, which involve not only the upper limbs but whole biokinetic chains. He also called for the need to pay special attention to the quality of the work along with its relatively small amount. Most of the assumptions he made were realized during the training of the group subjected to additional plyometric training. Mastalerz and Adamczyk (2015) also wrote about the effectiveness of this method, which further supports its implementation.

The obtained results indicate some imperfections of the original resistance training programme used in group 1. The exercises did not have a sufficient effect on the development of the ability to impart high speed to the ball during a throw. Although they provided a lower regression than the comparative group, this was not a satisfactory result, especially in the group subjected to additional plyometric training; but a statistically significant increase in the discussed capacity was noted. The probable cause of this progression was the use of medicine-ball throw exercises performed by the athletes in this group. Although the noted improvement was not large (on average 0.8 km/h), against the background of regressions recorded for the other two groups, it was still positive.

Conclusions

1. Advanced athletes, using appropriate resistance exercises, are able to increase ball throwing speed during a goal shot.
2. Dynamic resistance exercises based on two-handed medicine ball throws, performed from a stand throw, resulted in improved ball flight speed.
3. The resistance training programme used in this experiment, based on maximal strength and power exercises using a barbell, did not guarantee maintenance of the thrown ball flight speed at the beginning of the starting period.

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ILLINOIS AGILITY TEST IN ELITE JAPANESE FEMALE JUNIOR HANDBALL PLAYERS: RELATIONSHIP WITH PHYSICAL FACTORS AND A COMPARISON AMONG COMPETITIVE LEVELS

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Summary
We conducted a survey of Japanese female junior handball players of different competitive levels to clarify the relationship between the three running phases of the Illinois Agility Test (IAT) and the physical factors necessary for handball. Study results indicate that measuring of the IAT enables not only the measurement of the agility of female handball players but also the assessment of the ability to change direction, sprint performance, and aerobic capacity.

Keyword: handball, physical training, Illinois agility test, female junior players

Introduction

Handball is a complex intermittent game, which requires well-developed aerobic and anaerobic capacities (Delamarche et al. 1987, Gorostiaga et al. 2006). Motor ability, sprinting, jumping, flexibility, agility and throwing velocity represent physical activities that are considered important aspects of the game and contribute to the high performance of the team (Granados et al. 2007, Marques & Gonzalez-Badillo. 2006). Previous studies identified agility as one of the most important determinants of successful play in handball (Cavala & Katic. 2010, Vieira et al. 2013, Wagner et al. 2014).

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). Tanaka et al. (2009) proposed a figure-eight course (6m-9m-6m-9m: total of 30m) for assessing the change-of-direction skill of Japanese junior handball players. The Japanese National Training System (NTS) adopted this agility test in 2009 and is currently still using it. Meanwhile, in Spain, the National Sporting Talent Programme founded by the Spanish Handball Federation is conducting the Illinois Agility Test (IAT) as a measure of agility (Sosa Gonzalez et al. 2011). The IAT has long been used as a standard agility test. The IAT is still frequently used for the assessment of agility and speed in sport games (Young et al. 2001, Gambetta. 1996, Buttifant et al. 1999). However, there are few studies on the IAT in regards to young handball players. In addition, few studies have investigated the relationship between the IAT and the physical factors necessary for handball.

We conducted a survey at different competitive levels to clarify the relationships between the three running phases of the IAT and the physical factors necessary for handball. The objective of this study was to observe the correlation between female junior handball players' ability to change direction and success on the handball court.

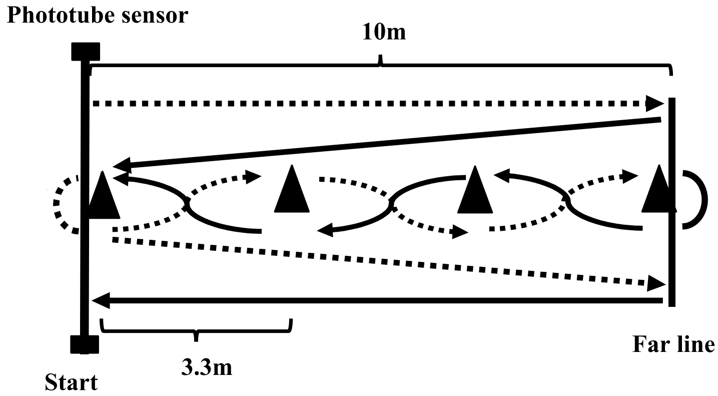
Method

Subjects:
Thirty-six Japanese female junior handball players participated in this study. We compared three groups of players at different competitive levels (elite players [EP]: players of national junior high school champion team (n=12), average players [AP]: players representing Fukuoka Prefecture

(n=12), below average players [BAP]: players belonging to normal club (n=12)). The participants' mean age, height, weight, body fat, and years of handball experience, were 14.7 ± 0.5 years, 159.1 ± 6.2 cm, 51.5 ± 6.3 kg, 18.3 ± 2.8%, and 4.5 ± 0.4 years, respectively (presented as mean ± standard deviation [SD]). Written explanations of the purpose, measurement items, and measurement methods were distributed to all participants, and their consents were obtained. Consents were also obtained for the use of the participant's individual measurement data.

Physical performance tests:
The following five measurements were conducted: Illinois Agility Test (IAT), 30m Straight Sprint test (30mSS), 30m Change of Direction Sprint test (30mCDS), Standing Long Jump (SLJ), and 20m Shuttle Running test (20mSR). The 30mCDS test involved the examinee sprinting in four straight lines (6m-9m-6m-9m) with three backward diagonal changes of direction at approximately 130^{o} (Tanaka. et al 2009).

Figure 1. Illinois agility test



Statistical analysis:
All data are presented as mean ± SD. The Pearson product-moment correlation coefficient was used to calculate the correlation between the results of the straight sprint, change-of-direction sprint, jumping ability, aerobic capacity, and Illinois Agility Test. We used one-way analysis of variance to compare physical strength by competitive levels and performed multiple comparison analysis. Statistical significance of the test results was set at 5%.

Results and discussion
Tables 1 and 2 show the physical characteristics and the results of the physical performance tests of the subjects, respectively. There were no significant differences in height, weight, and body fat among the three groups. Lean body mass in the AP group was significantly higher than that in the BAP group. The average height and weight of the U15 players who participated in the Japan Handball Association National Training System (NTS) Center Training from 2010 to 2012 were 166.7 ± 5.1 cm and 58.7 ± 6.3 kg, as reported by Moriguchi et al. (2013). Compared with this previous study, elite female junior handball players in this study were shorter and lighter.

Table 1. Physical characteristics of female junior handball players

	elite players	average players	below average players
Height (cm)	159.5±6.60	160.4±4.94	156.1±5.57
Weight (kg)	51.5±6.87	53.9±5.13	48.7±4.40
Body fat (%)	16.9±2.35	19.0±1.88	19.0±3.22
Lean body mass (kg)	42.7±4.84	43.6±4.19 [a]	39.4±3.05

a= significant differences between average players and below average players, $p< 0.05$

Table 2. Physical performance tests of female junior handball players

	elite players	average players	below average players
30m sprint (sec)	4.87±0.16 [d]	5.02±0.21	5.13±0.14
30m change of direction (sec)	7.15±0.12	7.22±0.28	7.42±0.25
Standing long jump (cm)	196.9±10.77 [b]	198.0±12.77 [a]	182.3±10.94
20m shuttle run (no. of times)	111.4±7.36 [c, d]	98.1±12.07 [a]	80.67±11.23

a= significant differences between average players and below average players, b= significant differences between elite players and below average players, c= significant differences between elite players and average players, $p< 0.05$,
d= significant differences between elite players and below average players, $p< 0.01$

The EP group was faster and jumped further than the BAP group, as demonstrated by the 30mSS ($p<0.01$) and the SLJ ($p<0.05$). There were no significant differences in the 30mSS and SLJ between the EP and AP groups. The EP group performed better in the 20mSR than the AP ($p<0.05$) and BAP groups ($p<0.01$). There were no significant differences in the 30mCDS among the three groups. According to Suzuki et al. (2013), the high school female handball players who won the national championship in Japan (U-18) were significantly faster than the lower ranking high school teams at the 30mSS and 30mCDS, and performed at a significantly higher level in the SLJ and 20mSR. In this study, those who won the national championship in the junior high school category (U-15) showed significantly better results than those of the lower ranking junior high school teams at the 30mSS, SLJ, and 20mSR, with a tendency to be quicker even at the 30mCDS. These results show that elite female junior handball players tend to have a greater anaerobic capacity such as sprinting and jumping ability as well as a greater aerobic capacity.

The results of the Illinois Agility Test are shown in Table 3. Total times of the IAT were 17.07 ± 0.42 sec (EP), 17.57 ± 0.48 sec (AP), and 18.28 ± 0.61 sec (BAP). These values indicate that as competitive levels increased, IAT times became significantly faster ($p<0.05$). The 20mSLSs of the IAT were 6.23 ± 0.20 sec (EP), 6.55 ± 0.23 sec (AP), and 6.86 ± 0.31 sec (BAP). These values indicate that as competitive levels increased, 20mSLS times of the IAT became significantly faster ($p<0.05$). The results of the one-way analysis of variance showed significant differences in the F-CDS of the IAT between competitive levels. A multiple comparison of the tests indicated significant differences between the EP and BAP groups ($p<0.01$), and the AP and BAP groups ($p<0.05$). There were no significant differences in the S-CDS of the IAT among the three groups. From these results, we conclude that elite female junior handball players have a greater ability to accelerate from a static position and greater running agility.

Table 3. Illinois agility test of female junior handball players

	elite players	average players	below average players
Total Time (sec)	17.07±0.42 [c,d]	17.57±0.48 [a]	18.28±0.61
First 20m sprint (sec)	5.48±0.22 [d]	5.57±0.19 [a]	5.90±0.26
20m slalom sprint (sec)	6.23±0.20 [c,d]	6.55±0.23 [a]	6.86±0.31
Second 20m sprint (sec)	5.36±0.13	5.46±0.16	5.52±0.41

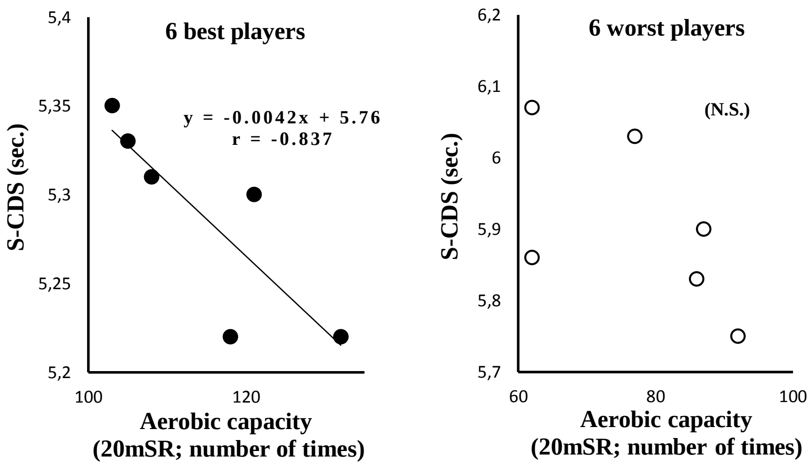
a= significant differences between average players and below average players, $p< 0.05$
c= significant differences between elite players and average players, $p< 0.05$
d= significant differences between elite players and below average players, $p< 0.01$

A significant correlation was observed between the F-CDS of the IAT and the 30mCDS in the three groups (EP: r=0.589, AP: r=0.582, BAP: r=0.608). A significant correlation was not observed between the F-CDS of the IAT and the 30mSS in the three groups. Although Moriguchi et al. (2015) confirmed the correlation between the 30mCDS and the 30mSS, in this study, there was no significant correlation between the F-CDS and the 30mSS. The angle in the changing direction in the F-CDS of the IAT (180 degrees) is greater than that in the 30mCDS (130 degrees). Thus, abilities such as deceleration, skills of changing direction, and leg strength may be more necessary than sprinting ability. Interestingly, as the competitive levels increased, the correlation between the F-CDS of the IAT and the SLJ decreased (EP: r= -0.386, AP: r= -0.446, BAP: r= -0.563). This is because as competitive levels increase, CDS ability is thought to be influenced by not only leg strength but also deceleration and skills of changing direction (Moriguchi et al. 2013).

A significant correlation was also observed between the 20mSLS of the IAT and the 30mSS in the three groups (EP: r=0.721, AP: r=0.607, BAP: r=0.793). However, a significant correlation was not observed between the 20mSLS of the IAT and the 30mCDS as well as the SLJ in the three groups. According to Huijgen et al. (2010), a significant correlation between the ability to change direction and the performance of slalom sprint (sprint weaving) was acknowledged. However, such a correlation was not observed in this study. In the previous study, 4 cones were placed in a zig-zag way, like poles used in slalom of alpine skiing. The width between cones was 2 meters. In the current study using the IAT, cones were placed in a straight line. In the study by Huijgen et al., subjects were required to have a greater ability to change direction as the width between cones was 2 meters. However, the current study assessed subjects' sprint performance more as the cones were placed in a straight line, and this accounted for the difference between this study and the previous study. This difference suggests that slalom sprint performance is influenced by the width between obstacles and the placement of these obstacles.

On the contrary, a significant correlation was not observed between the S-CDS of the IAT and the 30mCDS or the 30mSS or the SLJ in the three groups. The result of the S-CDS is thought to be influenced by other factors and not by the ability to change direction, acceleration ability, or leg strength. A correlation was observed between the S-CDS and the 20mSR of 6 players who ran faster than others per their total IAT time. However, no such correlation was observed in the 6 players who did poorly per their total IAT time (Figure 2). From these results, the S-CDS of the IAT is thought to be considerably influenced by aerobic capacity. Considering the small sample size of this study and the total movement time of 17 to 19 seconds, further studies to compare the results of lactic acid measurements, such as the 200m sprint or yo-yo intermittent recovery test Level 2 (Yo-Yo IR2), are needed.

Figure 2. Relationship between Aerobic capacity and S-CDS performance of the 6 best and worst players



The F-CDS of the IAT was found to be correlated with the results of the 30mCDS. The 20mSLS and 30mSS were also correlated with one another as were the S-CDS and 20mSR. These findings show that measuring the three different phases of the IAT enables not only the measurement of the agility of female handball players but also the assessment of the ability to change direction, sprint performance, and aerobic capacity.

The results of this study indicate that as competitive levels increased, total IAT times became significantly faster. Tanaka et al. (1999) confirmed the correlation between 30mCDS times and handball performance. Cavala & Katic. (2010), Vieira et al. (2013), and Wagner et al. (2014) insisted that the most important physical factor in handball is agility. A significant correlation between the total time of the IAT and the 30mCDS was observed (EP: r=0.655, AP: r=0.642, BAP: r=0.588). The 30mCDS has long been used to measure agility by the Japan Handball Association. In 2017, the NTS of the Japan Handball Association began using the IAT. The IAT is considered a valid method to assess various physical factors of athletes, including the agility of young female handball players. The IAT may also be used as a useful method to scout talented players.

Conclusion

In this study of female junior handball players, we found that as competitive levels rose, results of the IAT became significantly faster and that elite female junior handball players had a greater ability to accelerate from a static position and exhibited greater running agility. A correlation between the IAT and the physical factors necessary for handball was also observed.

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THE COMPARISON OF CUMULATIVE INDICATORS OF TEAM PLAYING PERFORMANCE
(OLYMPIC GAMES HANDBALL TOURNAMENTS 2008, 2012 AND 2016)

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IHF Executive Committee Member

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, 2012 and 2016 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. The aim is to compare the selected indicators between both genders and in the terms of time on the ending of three consecutive Olympic cycles.

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

Introduction
This study builds on our original performance on Second EHF Scientific Conference 2013. Based on the same methodological approaches we compare not only indicators of both genders, but also from a historical point of view and concerning performance groups (final ranking on OG).

Professional questions and premises
First
It is without the 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. It evokes 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. 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 the premise that the differences among the selected cumulative indicators of TPP in men’s and women’s teams do not have factual significant evidence.
Second
From the fifties of the twentieth century, the handball game has undergone extreme changes. The progressive changes are the result of increasing popularity of handball and related positive adjustments in the organization (especially the format and periodicity of the competitions), the modification and interpretation of the rules of game and the methodology of selection and preparation of top players. We have a wealth of data that documents long-term developmental changes. Our question is if these changes are significantly visible also on TTP indicators in approximately ten years period (starting with the building and preparation of the teams for OG 2008 and ending with OG 2016).
Third
The data gathered also provides an opportunity to examine the claim that there are an increasing number of top teams with the similar TPP characteristic. This will serve to divide the participating teams into three performance groups based on their final ranking in each of the three Olympic tournaments and the subsequent data comparison.

Subject
We summarized selected data from all the matches of both men and women at the Olympic Games (OG) handball tournaments 2008, 2012 and 2016. It was totally 236 matches (42 men´s, plus 42 women´s in Beijing 2008 and 38, plus 38 in London 2012 and also in Rio de Janeiro).

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, 2012 and 2016). 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 adults 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 resigned both 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) and 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
We follow the above defined areas; this means the gender comparison, the comparison of development trends and comparison of the equilibrium of performance group.

By analyzing the **efficiency of shots** in **Table 1** is possible to find and underline the following observations:

- **Total** efficiency of shots is similar in both genders on OG 2008 and 2012 and not significant according to our factual evidence, but difference in favor of men is significant on 2016. There is a trend towards improving the efficiency of shooting in both genders, but the improvement by men 2016 is very distinctive. The explanation may be the faster adaptation of male teams on rules adjustment with seven field players in attack. Figures do not confirm the assumed trend of equalization among three performance groups.
- The efficiency from the **pivot** position is similar with small increasing tendencies among OG 2008 and 2012, but on OG 2016 is visible decrease which is by female significant.
- 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. This explanation was not on OG 2016 confirmed.
- 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. On OG 2016 was the difference of shooting efficiency from back position clear significant (men 43,2 % and women 34,9 %).
- The efficiency of shots in **break through** situations increased for women between 2008 and 2012 on a similar level as for men, but on OG 2016 was significantly lower.
- Similar development is possible to notice concerning the efficiency in a **fast break** situation. The increase for women during the first four-year period was remarkable, but on OG 2016 was not any more improvement. By male teams was the improvement on OG 2016 in this indicator significant.
- On the other hand the significant differences of efficiency beneficially for the men in **7-meter** situation on OG 2008 and 2012 were on OG 2016 not confirmed.

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

- The percentage of goals achieved in the situations shooter against goalkeeper "face to face" (pivot and wing positions and fast break, break throw and 7m situations) considerably increased over eight years. For male teams nearly by three percent to 73,7 % and for female teams even significantly by 7,5 % to 81,0 %. This means that from back position is achieved by men only every fourth goal by female even just every fifth goal. This obviously has an impact on the effectiveness of goalkeeping.
- The percentage of goals from the **pivot** position was significantly higher for men in 2008, but in 2012 and 2016 the gender values come relatively close together. But on OG 2016 was a significant increase in the percentage share from this space.
- 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 was on all monitored OG higher for men. For both genders, however, the proportion of goals from the back space was on OG 2016 significantly reduced.
- The differences in the figures concerning the percentage of goals in **breakthrough** situations are not significant. Nevertheless because of the disadvantage of shots from longer distances, women use these individual actions little bit often.
- In the **fast break** situation, values are similar for both genders, with an evident tendency of decrease between OG 2008 and 2012. The reason was probably the trend of accenting the defense against fast breaks of opponents.

- In a **7-meter** situation a similar state as in breakthrough is visible (from same reasons).

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

- **Total** efficiency of goalkeeping was very similar for both genders and according to our factual evidence not significant on OG 2008 and 2012. For OG 2016 is significant by male goalies the decrease of 5 %. Nevertheless in the whole monitored period the effectiveness of defensive interventions of the goalkeepers gradually slightly decreases in both genders. Interestingly and unexpectedly, the smallest differences among the three performance groups were found on OG 2008 in men tournaments.
- Goalkeeping efficiency against shots from the **pivot** position presents in both genders categories often significant differences and fluctuations in both directions (up and down).
- Similar situation can be detected in women competition concerning the goalkeeping efficiency against the shots from the **wing** position (2008 was it 42,0 %, four years later decrease to 31,8 % and on 2016 again increase to 37,2 %. The efficiency of male goalies was extremely low on OG 2016 (26,0 %).
- Concerning the efficiency against the shots from the **back** position, the values are in both genders relatively balanced on 2008 and 2012 OG tournaments, with a small advantage for female goalkeepers. But very significant difference in the favor of ladies appeared on OG 2016.
- In a **break through** situation, both genders are in similar state like by back position.
- In the situation of a **fast break** is possible to identify a decreasing trend of efficiency especially for women.
- In the execution of a **7-meter** throw the female goalkeepers were significantly more successful as male on OG 2012, but on OG 2016 there was in female gender again a significant decline.

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

- The average **goals score** in the monitored period only slightly oscillated and is for women somewhat lower (on 2012 and 2016 at the limit of significance).
- The average number of **attacks** pro singular team in one match pointed out significant differences between men and women. On OG 2008 was average for women 6,5 attack higher than for men. On OG 2012 the difference decreased to 3,7 and on 2016 to 3,5 attacks. In both genders there is also a significantly decreasing tendency, by men in eight years from average 56,2 to 52,2 and by women from 62,7 to 55,7 attacks. It corresponds to the general trend to strengthen defense activities.
- Concerning technical **errors,** significant differences can be observed between the two genders. Here, it is also necessary to mention that on OG 2008 and 2012 the last performance groups (ranking 9-12) were significantly worse than groups 1-4 and 5-8. But it was no longer valid for OG 2016. The significantly higher number of technical errors by female teams in comparison to men is very probably the reason for the higher number of attacks. It is simultaneously the explication why are the shooting and goalkeeping average efficiency on a similar level for both genders.

Conclusion

Regarding the above formulated professional questions it can be answered with accordance to the analyses of reachable cumulative indicators of TPP and with the use of defined assessment criteria that 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. General development trends are significantly visible in increasing the proportion of goals achieved from the situation “face to face”. This, of course, causes an increase in the efficiency of the shooting and a decrease in the defensive success of the goalkeepers. There is also a trend towards reducing the number of attacks and technical errors. The deepening of the equilibrium of the participating teams could only be confirmed exceptionally (e.g. technical errors).

Enclosures:
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

Table 1: Efficiency of Shots OG 2008 – 2012 - 2016

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
M 2016	1-4	32/2	217 - 305	71,1	145 - 210	69,0	259 - 533	48,6	80 - 102	78,4	151 - 184	82,1	87 -110	79,1	939 - 1444	65,0
	5-8	24/2	168 - 252	66,7	92 - 137	67,2	182 - 435	41,8	54 - 74	73,0	85 - 105	81,0	72 - 93	77,4	653 - 1096	59,6
	9-12	20/2	136 - 208	65,4	73 - 115	63,5	115 - 318	36,2	55 - 74	74,3	57 - 76	75,0	53 - 70	75,7	489 - 861	56,8
	Total	38	521 - 765	68,1	310 - 462	67,1	556 - 1286	43,2	189 - 250	75,6	293 - 365	80,3	212 - 273	77,7	2081 - 3401	61,2
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
W 2016	1-4	32/2	236 - 361	65,4	124 - 215	57,7	171 - 459	37,3	111 - 144	77,1	152 - 206	73.8	113 - 149	75,8	907 - 1534	59,1
	5-8	24/2	170 - 268	63,4	72 - 155	46,5	113 - 326	34,7	68 - 96	70,8	101 - 125	80,1	101 - 122	82,8	625 - 1092	57,2
	9-12	20/2	115 - 210	54,8	83 - 168	49,4	92 - 292	31,5	33 - 60	55,0	60 - 82	73,2	63 - 92	68,5	446 - 904	49,3
	Total	38	521 - 839	62,1	279 - 538	51,9	376 - 1077	34,9	212 - 300	70,7	313 - 413	75,8	277 - 363	76,3	1978 - 3530	56,0

(Taborsky 2017)

Table 2: Percentage of Goals from Different Positions and Situations OG 2008 – 2012 - 2016

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
M 2016	**1-4**	*32/2*	217	**23,1**	145	**15,4**	259	**27,6**	80	**8,5**	151	**16,1**	87	**9,3**	939	100
	5-8	*24/2*	168	**25,7**	92	**14,1**	182	**27,9**	54	**8,3**	85	**13,0**	72	**11,0**	653	100
	9-12	*20/2*	136	**27,8**	73	**14,9**	115	**23,5**	55	**11,3**	57	**11,7**	53	**10,8**	489	100
	Total	**38**	521	**25,0**	310	**14,9**	556	**26,7**	189	**9,1**	293	**14,1**	212	**10,2**	2081	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
W 2016	**1-4**	*32/2*	236	**26,0**	124	**13,7**	171	**18,9**	111	**12,2**	152	**16,7**	113	**12,5**	907	100
	5-8	*24/2*	170	**27,2**	72	**11,5**	113	**18,1**	68	**10,8**	101	**16,2**	101	**16,2**	625	100
	9-12	*20/2*	115	**25,8**	83	**18,6**	92	**20,6**	33	**7,4**	60	**13,5**	63	**14,1**	446	100
	Total	**38**	521	**26,4**	279	**14,1**	376	**19,0**	212	**10,7**	313	**15,8**	277	**14,0**	1978	100

(Taborsky 2017)

Table 3: Goalkeeping Efficiency OG 2008 – 2012 - 2016

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
M 2016	1-4	32/2	69/286	24,1	37/147	25,2	196/471	41,6	19/02	18,6	20/111	18,2	23/11	20,7	364 / 1228	29,6
	5-8	24/2	56/234	23,9	42/139	30,2	108/265	40,8	12/75	16,0	16/123	13,0	10/80	12,5	244 / 916	26,6
	9-12	20/2	49/175	28,0	30/133	22,6	81/205	39,5	9/52	17,3	19/114	16,7	16/70	22,9	204 / 749	27,2
	Total	38	174/695	25,0	109/419	26,0	385/941	40,9	40/229	17,5	55/348	15,8	49/261	18,8	812 / 2893	28,1
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
W 2016	1-4	32/2	88/315	27,9	60/183	32,8	203/368	55,2	25/103	24,3	22/115	19,1	27/158	17,1	425 / 1242	34,2
	5-8	24/2	74/236	31,4	69/148	46,6	83/193	43,0	16/97	16,5	24/134	17,9	15/98	15,3	281 / 906	31,0
	9-12	20/2	59/191	30,9	36/113	31,9	78/179	43,6	18/71	25,4	18/128	14,1	13/76	17,1	222 / 758	29,3
	Total	38	221/742	29,8	165/444	37,2	364/740	49,2	59/271	21,8	64/377	17,0	55/332	16,6	928 / 2906	31,9

(Taborsky 2017)

Table 4: Cumulative Statistics of Scores, Attacks, Technical Errors and Efficiencies OG 2008 – 2012 - 2016

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
M 2016	1-4	32/2	939 : 864	29,3 : 27,0	+ 2,3	1679	52,5	327	10,2	55,9	65,0	29,6
	5-8	24/2	653 : 672	27,2 : 28,0	- 0,8	1258	52,4	261	10,9	51,9	59,6	26,6
	9-12	20/2	489 : 545	24,5 : 27,3	- 2,8	1028	51,4	235	11,8	47,6	56,8	27,2
	Total	38	2081:2081	27,4 : 27,4	- - -	3965	52,2	823	10,8	52,5	61,2	28,1
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
W 2016	1-4	32/2	907 : 817	28,3 : 25,5	+ 2,8	1802	56,3	383	12,0	50,3	59,1	34,2
	5-8	24/2	625 : 625	26,0 : 26,0	0	1328	55,3	319	13,3	47,1	57,2	31,0
	9-12	20/2	446 : 536	22,3 : 26,8	- 4,5	1101	55,1	278	13,9	40,5	49,3	29,3
	Total	38	1978:1978	26,0 : 26:0	-	4231	55,7	980	12,9	46,8	56,0	31,9

(Taborsky 2017)

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FURTHER TOPICS PRESENTED AT THE SCIENTIFIC CONFERENCE

BIOMECHANICAL PROFILE OF SPORT SHOULDER

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The aim of the study was to compare shoulder rotation ranges and deficits between professional handball players and the control group of healthy non-athletes and to examine any differences in level of shoulder joint position sense (JPS), muscle balance, strength, endurance and power.

87 professional male handball players and 41 healthy male volunteers. Study protocol included: measurement of range of internal and external rotation, measurement of shoulder proprioception using the electronic goniometer, measurement of isokinetic shoulder function on Biodex System 3 PRO, and ultrasound scan.

There were no significant differences between rotation deficits, external rotation gain and occurrence of rotation deficits comparing athlete group to the control group. Athletes with shoulder pain had significantly decreased external rotation and total arch of motion. Internal impingement coexisted with decreased rotations. The handball players present superior shoulder joint matching ability in the throwing shoulder at highest ranges of motion when compared to the contralateral one and the dominant shoulder of the non-athlete population and significantly greater isokinetic parameters comparing to control group.

The results are important for the application and interpretation of biomechanical parameters of the shoulder among handball players and can be use in both rehabilitation and prevention of shoulder injuries.

The project was funded by the National Science Centre based on decision number DEC-2011/01/B/NZ7/03596.

SOCIAL AESTHETICS AND HANDBALL – THEORY AND PRACTICE

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The main focus of social aesthetics as a multidisciplinary research domain is to investigate the „Hows" for a beautiful and well-made social life. European history of ideas teaches us that beauty is not just an adornment to life but also a major source of strength of life. Moreover, positive aesthetic experience is a major power for mental health (Musalek 2013). The knowledge about the „Hows" of our social co-existence and interindividual encounter in general and in the field of interest handball in particular provides the indispensable foundation for effective aesthetic interventions focussing on the mental health for all people involved in handball, e.g. players, trainers, coaches, referees, sport officials and supporters. The main domains of social aesthetic in daily handball practice are to provide frames for the development of possibilities for an aesthetic change, to create atmospheres and scopes for beautiful encounter and to promote awareness and accessibility. Furthermore it focuses on the differences between aesthetic measures as fairness, and ethical measures as justice, and last not least to experience self-friendship and hospitality, to become acquainted with astonishment/amazement and to recognize loss as a chance and crisis as a starting point for new ways to go. In social aesthetics to be understood as the science of beauty in interpersonal relationships we acquire knowledge which may become the basis of human-centred approaches to mental health prevention in the field of handball.

Musalek, M (2013) Health, Well-being and Beauty in Medicine. Topoi 32 (2), 171–177

ANTHROPOMETRIC AND PYSYOLOGICAL CHARACTARISTIC OF ELITE HANDBALL PLAYERS – INFLUENCE OF PLAYING POSITION

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Background: Handball game is a dynamic team game that combines movements that are explosive in nature.The aim of the current study was to evaluate anthropometrical characteristics and physiological attributes of elite handball players and quantify differences if exist according to player position.

Methods: The sample of subjects consisted of 35 handball players from the Israel Junior (U20) and national team (mean age 20.79±1.36yrs). All participants performed a battery of motor and physical tests reflecting handball physiological demands. The array of tests included: anthropometric measures (Height, body mass, %fat), countermovement jump (CMJ), 5m and 20m sprint, 3000m run, 1RM squat, 1RM bench press and LESS test. The results were compared based on playing position and to the Norwegian national team and 1st division players.

Results: Wings players presented better performance abilities in 5m and 20m sprint, CMJ and 3000m run compared to other player's positions. Squat's relative strength was better in the wings positions compared to pivots, goalkeepers and backs. The same trend was presented in 1RM relative strength of the bench press, wings performed better than other playing positions. Mean LESS test score was 5.68±1.3.

When the results were compared to the Norwegian national team and 1st division players, Israel's national team athletes (U20) presented lower results and physical abilities across all playing positions.

Conclusions: The findings demonstrated the varying on-court demands and the different physiological characteristics reflecting each playing positions. Physical training of handball players should therefore be individualized based on player's position, current ability and game's demands.

FEMALE ADOLESCENT ELITE HANDBALL PLAYERS ARE MORE SUSCEPTIBLE TO SHOULDER PROBLEMS:
THE KAROLINSKA HANDBALL STUDY (KHAST)

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Introduction: Shoulder problems are frequent among senior elite handball players. The objective of this study was to assess the prevalence of shoulder problems among adolescent elite handball players and investigate if there are any differences among gender, playing position, age or playing level.

Material and methods: 471 players (15-18 years, 54% female) completed a comprehensive baseline questionnaire including questions regarding shoulder problems the past season. The players were then monitored prospectively every week for one competition season regarding shoulder problems. Generalised linear models with a binomial link function were used to calculate a prevalence ratio (PR) with 95% confidence interval (CI).

Results: 110 players reported having substantial shoulder problems at some point during the follow-up season with a significantly higher prevalence in female players (PR 1.46, 95% 1.04-2.10) and in backcourt players (PR 1.58, 95% CI 1.08-2.32). The prevalence did not differ among age (PR 1.21 95% CI 0.88-1.67) or playing levels (PR 1.09 95% CI 0.76-1.56).

Conclusions: The season prevalence of substantial shoulder problems in adolescent elite handball players was high and higher among females and backcourt players. These findings warrant the need of introduction and implementation of evidence-based prevention strategies for shoulder problems in handball players already before 15 years of age.

EFFECT OF FATIGUE ON PROPRIOCEPTION AND EXTERNAL ROTATOR ECCENTRIC REACTION IN THROWERS WITH OR WITHOUT PAIN

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Introduction: Shoulder overload injuries are a major problem in throwing sports [1]. Throwing is characterised by a forceful internal rotation and after ball release the internal rotation is braked by eccentric action of the external rotators. External rotator strength has previously been related to increased risk of shoulder injury [2]. Also proprioception is considered important for functional stability of the shoulder, and previously proprioceptive measures like threshold to detection of movement or reproduction of position have been used to evaluate shoulder function in athletes [3]. The objective of this preliminary study was a) to examine the potential differences in shoulder proprioception and external rotator activation between athletes with and without shoulder pain, and b) to investigate how fatigue influences shoulder proprioception, using a novel, and more dynamic, method of measuring detection of movement in the shoulder.

Methods: 24 female elite level European team handball athletes (aged 18-26 yrs) volunteered to participate. 10 players were participating in training and games despite pain, and 14 players without symptoms served as control group. First, maximal isometric internal rotation strength (MVIC) was measured in a supine position with the shoulder and elbow in 90° abduction and flexion, respectively, using a handheld dynamometer. Subsequently, the subjects were seated upright with the upper arm supported in 90° abduction in the scapula plane, the elbow in 90° flexion and the forearm vertical. From the back side of a firmly attached wrist band, a cable was directed around a pulley to an electromagnet with a load attached. The subject would hold the load above the ground by a slight internal rotation of the shoulder joint to a vertical position of the forearm, and as such be in a position similar to a throwing position. At a random interval 1-3 second after lifting the load off the ground, the load was released and the shoulder would internally rotate. The subjects were instructed to, as quickly as possible, decelerate the internal rotation, thereby resembling the situation after ball release in throwing. An accelerometer was attached to the wrist to record the movements. After integration of the acceleration data, the time from release to the start of deceleration (reaction time, RT) was determined as the time to peak velocity. This outcome parameter is proposed to rely on the proprioceptive ability to detect onset of movement, however in a more dynamic –and functional- manner, compared to other measures of thresholds to detection of movement. The time from the start of the deceleration to the end of internal rotation, i.e. the instant of zero velocity was defined as deceleration time (DT). DT may rely on the ability to forcefully activate the external rotators. The total stop time was the sum of RT and DT, and by further integration of the velocity curve the total distance moved was obtained, and these parameters comprised both RT and DT as an overall measure of shoulder stability. After thorough practice, 5 test trials were performed. The tests were performed with a load corresponding to 30 % MVIC.

Data was collected before and after a functional fatiguing protocol consisting of alternating 5 maximal throws with 5 submaximal throws for a total of 60 throws. Level of fatigue was rated using a 10-point Borg-scale. A two-way repeated measures ANOVA was used to examine differences between groups and effect of fatigue.

Results and Discussion: Level of fatigue increased from 2.2 to 6.2 (p>0.001) on the 10-point Borg scale for both groups combined, but no difference in fatigue development between groups were found. Also no difference in MVIC between groups was found. Significantly slower RT was observed in the group with pain (pain group: 101 ms (SD: 8.7) vs. control group: 93 ms (SD: 9.5), p=0.03, effect size: 0.83), which may indicate that the ability to detect the sudden perturbation was diminished in this group. However, the observed difference did not change with fatigue, indicating that proprioception is not affected by fatigue, as also shown in other studies (e.g. [2]). No differences between groups were found in the other outcome parameters, which may indicate that the ability to activate the external rotators is not influenced by pain, or that lack of external rotator activation was not the problem in this small sample of athletes. No effect of fatigue was detected in any parameter, but a numeric, yet non-significant, increase in DT after fatigue corresponding to 10% was observed for the group with pain compared to the control group (7 ms (SD:17) vs. 1 ms (SD:6), respectively, p=0.22). This may be further explored in a larger study.

Conclusions: This new approach to testing shoulder stability during conditions more close to functional throwing conditions was able to distinguish athletes throwing with pain from non-symptomatic control subjects, showing a slower reaction time, but no effect of fatigue. The present study cannot determine whether this observed difference is a result of pain or a factor contributing to a poorer stability, potentially resulting in pain. The potential of this test may be further explored in a larger prospective study.

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RETURN TO SPORTS PARTICIPATION OF PATIENTS WITH CHRONIC ANKLE INSTABILITY

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Due to many problems associated with ankle sprain and possible long lasting sequelae of chronic ankle instability, great emphasis should be placed on introducing evidence based and proper return to sport criteria, that can help define the current stage of rehabilitation and reduce the risk of another injury. The aim of this nonrandomized-controlled trial is to obtain those measures by introducing the Functional Biomechanical Evaluation (FBE) as a way to test the readiness to return to sports participation.

Thirty subjects with chronic ankle instability after an initial ankle sprain were assigned to the intervention group (18 men and 12 women) that went through the rehabilitation process that ended when they obtained good results on the FBE. The control group consisted of thirty healthy participants without ankle instability and with no episodes of ankle sprains (18 men and 12 women). Outcome measures consisted of self-assessed disability, weight-bearing dorsiflexion lunge test, functional hop testing, Star Excursion Balance Test reach distances, Functional Movement Screen and postural control test on DELOS using the Riva method. Follow up for injury rate was made after 12 months.

Patients that were treated conservatively reached similar or better scores than those obtained by the control group on the FBE after 11,7±2,4 weeks. After 12 months there were 3 ankle sprains and one episode of giving way in the intervention group.

The objective criteria that should be met before returning to sport are an important factor that could reduce the risk of sustaining another injury.

INJURY RISK AND SHOULDER PROFILE IN HANDBALL ATHLETES – A LITERATURE OVERVIEW

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Handball athletes are routinely exposed to direct and indirect trauma to their throwing shoulder. Due to the violent and repetitive nature of the throwing motion, these athletes also commonly present with functional adaptations of the throwing shoulder that stem from osseous and soft tissue structural changes. Although these adaptations might occur commonly among handball athletes, such changes can have detrimental effects, often leading to injury and time lost from competition, when they are not managed correctly through preventative exercises. With a literature overview due to the profile, workload and risk factors to a handball athlete´s shoulder we present the current data and introduce therapeutic strategies to reduce an injury percentage at the shoulder joint.

PHYSIOLOGICAL REQUIREMENTS OF ELITE HANDBALL – MEASURED WITH A COMBINATION OF LOCAL POSITIONING SYSTEM AND HEART RATE MONITORING

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For all athletes, it is important to adjust training plans and competition schedule according to each individual's specific traits and situation. This is crucial in team sports, where players, despite being involved in the same sport, and even on the same team, may have very different physiological capacities and, also have completed a wide variety of work in both training and match situations. A first step towards being able to carry out individualized training is to accurately measure the amount of stress (physiological burden) for each individual. The purpose of the study was to create a comprehensive picture of the physical requirements of elite handball matches, and further investigate how the relationship between work load and physical capacity impacts performance.

Heart rate measurements have since decades been used to quantify the relative work, and GPS measurement as a tool for objective values has been available for outdoor sports for about ten years, but GPS is not possible to use indoors. We have used a new technology with a similar system for indoor use called Local Positioning System (LPS) (Kinexon Precision Technologies, Münich, Germany) to record and analyze the players' motion during games, and we have combined that technology with data from accelerometry, gyroscope and heart rate measurements.

So far, 42 handball matches have been measured and analyzed, ranging from juniors (9 games U21 men's national team) to seniors, men and women, and both in Sweden's highest league and between national teams (Women: 8 national and 7 international games; Men: 14 national and 4 international games).

A first "result" is that the categorization of motion patterns need to be adapted to each sport. For example, some moves that should be counted as accelerations in handball are not recognized by the system, simply because it has been adapted to the pattern of motion on the much larger soccer field. This is similarly important to realize when comparing results for handball's physiological requirements reached using other technologies. In this presentation, we will in part discuss the future technological opportunities, and in part report descriptive results, including how fast and far the players move, as well as differences between men and women, between national and international games, and between juniors and seniors.

DOPING IN HANDBALL: NEED FOR ACTION?

Prof. Hans Holdhaus
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Following WADA´s statistic 2015, Handball can be qualified as "Clean Sports". 3739 doping controls and only 29 positive cases (0,7 %) underlines that doping in handball is not a real problem. Less than 50% of the AAFs were from European players, using anabolic, beta-2-agonist, diuretics, stimulants, glucocorticoids and cannabis. Further investigations show that some of the AAF´s were unintentionally and the result of lack of knowledge and awareness on anti-doping rules.

Ignorance or little interest in the rules do not protect the player or the team from punishment, but damage the image of Handball.

The Handball community (EHF, National Federations, Clubs) has to set clear steps against doping. And the most important step is still education and information. Players should not only be informed about the current rules, the procedure of doping controls, TUE procedure, whereabouts regulations, etc. but also about the danger of using non-certified nutrition supplements or taking medicine from their "house-pharmacy" without proofing the substances.

It must be an obligation for all institutions involved in Handball to ensure that all players, from younger age category to elite level get detailed information on anti-doping. Small-talks during doping controls always show that there is still a necessity to act.

One of the main goals of EHF-ADU is therefor to focus more on education programs and to assist the teams in their anti-doping work.

CLINICAL AND BIOMECHANICAL RECOVERY FOLLOWING SHOULDER INSTABILITY AND LABRAL REPAIR

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Clinical and biomechanical testing help in objective evaluation and decision making of the patients' return to sport or heavy labour following shoulder surgery. The recovery may run differently in various instability cases (anterior vs posterior) and procedures (labral repair vs. Latarjet procedure). The aim of the study was to evaluate the recovery of range of motion (ROM) and isokinetic parameters following surgical treatment for shoulder instability.

Study was based on 61 patients operated in 2014-2016 for shoulder instability and having both clinical and isokinetic testing. Anterior instability was addressed by labral repair in 34 and by Latarjet procedure in 10 patients. Posterior instability was addressed by labral repair in 17 patients. ROM was evaluated preoperatively, at 8, 14 and 24 weeks postoperatively and isokinetic testing at 14 and 24 weeks postoperatively.

Full range of flexion and abduction was achieved at 14 weeks following operation. External rotation (ER) was regained at 24 weeks, however it was significantly lower in Latarjet group. Isokinetic parameters improved over time, however some deficits in ER measures remained (8-12% at lowest, 33-55% at highest velocities). Posterior instability group had significantly better results comparing to other groups, especially to Latarjet. Lowest values were recorded for Latarjet patients. Full strength and ROM recovery is possible within 6 months for posterior labral repair. Patients treated for anterior instability with both labral repair and coracoid transfer take longer to fully recover. Latarjet procedure provided lowest parameters in ER and strength testing.

INFERIOR SHOULDER JOINT POSITION SENSE IN JUNIOR HANDBALL PLAYERS

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It is controversial whether throwing sports and sports training affects shoulder proprioception. The aim of the study was to evaluate and compare the joint position sense (JPS) of both shoulders of senior and junior male handball players, and non-athletic healthy male individuals.

90 senior and 19 junior handball players from national handball teams, and 32 healthy male volunteers had participated in the study. The protocol had included the measurement of dominant and non-dominant shoulder proprioception by active reproduction of the joint position and the comparison of results between groups. Measurement included flexion, abduction, internal and external rotation. JPS had been measured with electronic goniometer.

JPS of the junior throwing shoulder had proven to be significantly worse compared to the throwing shoulder of the senior handball players and to the dominant shoulder of the control group at highest ranges of flexion (4,7°±2,3 vs. 3,0°±1,6 vs. 3,6°±1,5) and abduction (8,9°±9,9 vs. 3,6°±2,6 vs. 4,5°±2,1). There was no difference in joint position matching between shoulders among junior handball players and control group in contrast to senior handball players.

Junior handball players showed significantly inferior JPS in the throwing shoulder at highest ranges of flexion and abduction when compared to senior athletes and control group. This might be related to a younger age and less experience in handball specific training. It can be hypothesized that handball training improves shoulder proprioception as shown by superior values of JPS in senior athletes when compared to younger players and non-athletic population.

INFLUENCE OF SHOULDER PATHOLOGY ON SHOULDER JOINT POSITION SENSE (JPS) IN PROFESSIONAL MALE HANDBALL PLAYERS

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The purpose of the study was to correlate the JPS to shoulder rotation deficits, shoulder pain and morphological changes in throwing shoulder detected by the ultrasound scan among handball players. 90 professional male handball players participated in the study.

Among players with internal rotation deficit (GIRD) and total arch of motion deficit (TAMD) significant differences were observed for the throwing shoulder for flexion, internal and external rotation movements. The incidence of pain in the throwing shoulder were 41% (n=36). An ultrasound scan revealed partial RC damage from the articular side among 14% (n=12) and an internal impingement of the postero-superior rotator cuff part among 15% (n=13) of handball players. Significant differences were observed for the throwing shoulder for the abduction in the case of an RC damage and for the flexion in the case of an internal impingement. No significant differences between sides were found in the case of shoulder pain.

Handball players with a clinically significant GIRD (>25°) and greater TAMD display a higher level of proprioceptive sensation in throwing shoulder at higher internal rotation angle positions. Handball players who display features of RC damage show a higher level of proprioceptive sensation in the throwing shoulder at higher abduction angles; handball players which display features of internal impingement show a higher level of deep feeling in the throwing shoulder at higher flexion angles; presence of moderate pain in the shoulder does not affect the level of joint position sense in throwing shoulder.

ISOKINETIC MUSCLE PERFORMANCE IN MALE PROFESSIONAL HANDBALL PLAYERS

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Muscle strength and endurance of the shoulder rotators is important for overhead throwing performance and dynamic glenohumeral stability. The aim of the study was to evaluate the external (ER) and internal rotator (IR) muscles isokinetic peak torque, total work and strength ratios in handball players. The pilot studies included 48 professional handball players of average age 24.0 (± 4.5 years), height 187,1 (±5,9) and weight 91,0 (±11,6). Isokinetic tests were performed concentrically at 180 and 270 deg/s using Biodex System in standard sitting position.

The differences between the athletes and controls regarding the peak torque at 180 deg/s and total work at 270 deg/s of the ER and IR muscles for dominant and non dominant shoulder were statistically significant. The control group presented higher ratios (D85,8±26,9; ND82,8±23,4) than handball players (D65,4±13,3; ND63,0±16,0). There were statistical differences between dominant and non dominant shoulder in both group for total work of the ER muscles. There were no statistical differences between dominant and non dominant shoulder in both group for peak torque of the ER and IR muscles.

Handball players present higher isokinetic parameters comparing to normal population. The study establishes additional normative data on ER and IR muscle torque and total work on high-level male handball players.

The project was funded by the National Science Center based on decision number DEC-2011/01/B/NZ7/03596.

INFLUENCE OF PLAYING POSITION ON ISOKINETIC PARAMETERS OF PROFESSIONAL MALE HANDBALL PLAYERS

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Court and phases of the game dictate the specific repertoire of technical and tactical elements a player should perform in a particular moment of a game. Due to that, the players can be discriminated among themselves with respect to a particular playing position. The aim of the study was to determine the influence of playing position on isokinetic parameters of professional male handball players.

46 (26 back court players, 15 wing attack players, 5 pivot players) professional handball players of average age 24 (± 4.5 years), height 187,4 (±5,8) and weight 91,8 (±10,7).

Data comparing differences in peak torque (PT), peak torque to body weight (PT/BW), total work (TW), average power (AP) and ratio of internally (IR) and externally (ER) rotating muscles in correlation to players position were analyzed for statistical significance using a paired t-test with a significance set at 0.05.

Pivots are characterized with higher isokinetic parameters comparing to backs and wings. Statistically significant results were obtained for PT IR (69,7 ±12,4), TW ER (851,3 ±330,1) & IR (1361,8 ±352,8), AP ER (78,5 ±29,9) & IR (112,6 ±42,2) for dominant arm, and PT ER (44,0 ±12,7) & IR (71,4 ±8,7), PT/BW IR (64,1 ±9,3), TW ER (673,9 ±288,2) & IR (1335,6 ±244,2), AP IR (123,4 ±27,2) for non-dominant arm. There were no differences between backs and wings.

The project was funded by the National Science Center based on decision number DEC-2011/01/B/NZ7/03596.

A FOCUS ON ACL INJURIES IN HANDBALL – WHERE WE ARE AND WHERE WE'RE GOING

Lior Laver
ESSKA Basic Science Research Committee Board Member

Injuries to the lower extremities are very common in handball, and most studies show that most acute injuries in handball involve the lower extremities, regardless of age and gender Although the most frequent injuries reported in handball are to the ankle (8–45 %), the most severe injuries occur at the knee (7–27 %) causing the longest absence from. Injuries to the Anterior Cruciate Ligament (ACL) represent one of the most severe injuries in handball, and several studies have reported the incidence of ACL injuries. Strand et al. studied top-level players in Norway over 10 seasons (from 1979 to 1989) and reported the incidence of ACL injury was found to be highest among women (0.82 ACL injuries/1,000 match hours versus 0.31 injuries per 1,000 match hours (Strand et al. 1990). In 1997, Myklebust et al. recorded ACL injuries during two seasons (1989/1990 and 1990/1991) in Norwegian elite handball players (Myklebust et al. 1997). They found the match injury rate for men to be 0.54 injuries/1,000 match hours and 1.62/1,000 h for women (3 X the rate for men).

At the second division, the rate for men was found to be 0.84 injuries/1,000 match hours and 1.82/1,000 h for women (2.2 x the rate for men) and at the third division, 0.27/1,000 h for men and 0.72/1,000 h for women (2.7 x the rate for men) (Myklebust et al. 1997). Myklebust et al. later (1998) performed a prospective study in 24 Norwegian elite teams over three seasons (seasons 1993/1994 through 1995/1996). They recorded a total of 5 ACL injuries in men and 23 in women (Myklebust et al. 1998). The overall rate of ACL injury was calculated to be 0.06+/-0.03 injuries/1,000 activity hours for men and 0.31/1,000 h for women. The rate during competition was 0.23 +/-0.13 injuries/1,000 match hours for men and 1.6/1,000 h for women. This study showed a fivefold higher overall risk for ACL injury among women compared to men and a nearly sevenfold higher risk of match injury in women.

The reason for the marked gender difference is unknown, but several hypotheses have been suggested, both intrinsic (e.g., anatomic, strength, coordination, hormonal, level of skill, and conditioning) and extrinsic (e.g., shoe and surface type). Myklebust et al. followed up with another prospective study of 60 women's teams in the top three divisions in Norway over one season (1998–1999) (Myklebust et al. 2003a).

The overall incidence of ACL injury in all three divisions was 3.07 % (29 injuries in 942 players); however, in the elite level, the incidence was significantly higher, with 5.77 % (13 injuries in 225 players). The overall rate in all three divisions was found to be 1.48/1,000 match hours but was 2.79/1,000 match hours at the elite level. Olsen et al. (2003) pooled the data collected in the three previous studies by Myklebust et al. (1997, 1998, 2003b). ACL injuries had been prospectively registered for seven seasons during which 9 ACL injuries occurred in regular league matches in men, providing a rate of 0.24 _ 0.09 injuries/1,000 match hours.

In women, however, there were a total of 44 ACL injuries for a rate of 0.77+/-0.04 injuries/1,000 match hours. Practically, an international elite team has in average 6–10 h of pure handball training weekly. Other physical conditioning and training and approximately two matches a week adds to this. This adds up to about 300 h of handball training and 80 matches a year. 80 matches translate to 560 h of exposure per team, and with the incidence of 0.54 ACL injuries/1,000 match hours found at the highest performance level by Myklebust et al. in 1997, this translates to 0.3 ACL injuries in matches per team over a competitive year (Myklebust et al. 1997).

Injury prevention has been proven effective in handball players, including with regards to reduction of the incidence of ACL injuries. However, it seems that compliance still plays a crucial role in the success of prevention programs. Methods to implement injury prevention with high rates of compliance are still needed and better practical strategies are necessary. The role of the coach may be a crucial point in the success of such programs.

RECOVERY AND RETURN TO SPORT FROM SHOULDER INJURY AND SURGERY

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Shoulder is at risk of injury or overuse in every throwing athlete. When affected, it may stop the athlete from play. One of the major concerns for the athlete, but also for the team, coach, family and medical stuff is safe return to the training and game. The concerns include time of recovery and criteria to let the athlete return to play (RTP).

RTP has been defined as medical clearance of an athlete for full participation in sport without restriction (strength and conditioning, practice, and competition). So, the goal of medical team in case of unhappy event is to return injured to practice or competition without putting individual or others at risk of another injury or illness. In order to realize the goal the process should include: proper planning, evaluation, treatment, rehabilitation and finally RTP. In 2002 and 2012 consensus statement has been published by American societies regarding the criteria or RTP, including: restoration of function and health, performance, no-risk, compliance with regulations. Decision based model has been proposed by Creighton DW at al.

The available EBM data and our unit's experience will be presented to support the choice of criteria, time and measures in evaluation of athlete recovering from injury or surgery of the shoulder, as well as expected success rates of RTP after particular clinical scenarios.

PRP THERAPIES IN UPPER LIMB ORTHOPEDICS: APPLICATIONS AND EVIDENCE BASED RECOMMENDATIONS

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Platelet reach plasma (PRP) has gain its popularity in recent decade. It has mostly been addressing the soft tissue problems when regeneration is a major issue. It has also been a matter of controversy with scientific knowledge giving sometimes contradicting results. A lot of confusion in its efficacy has been raised. Therefore, the aim of this presentation is to review current basic science and clinical literature on PRP and its application in upper limb problems. It has been shown that PRP has an proliferative effect on human cells (myocytes, fibrocytes and osteocytes).

However, it remains unclear what is the optimal concertation and formula for the treatment of various cell types. Most clinical applications that has been studied concern rotator cuff and tennis elbow. There has been some evidence that PRP might improve healing of the rotator following repair. However not all the studies confirm the effect and many of them are suboptimal quality to yield strong conclusions. PRP seems also to improve the patients' symptoms in lateral elbow pain. But also in this condition results are contradictory, mostly due to different study designs and PRP formula preparations.

Conclusions: There is some data that PRP therapy in particular upper limb conditions improves tissue healing, decreases pain, improves function, remaining safe but expansive procedure. However studies are few, with limitation and results sometimes conflicting.

SPORT INJURY AND OVERUSE MONITORING SYSTEM (SIOMS)- DEVELOPMENT AND EARLY RESULTS

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The purpose of our study was to build the system allowing to monitor not only traumatic but also overuse injuries (SIOMS) with the use of mobile technology of data collection.

Methods were based on staged preparation of the register (SIOMS). Then pre-final version was transferred into electronic version based on mobile application. After final modifications application was used to collect the data from Polish National team during the 2016 Olympic Games and final preparation camp. Reporting has been done by a team physician.

Results: SIOMS mobile application has proved to be easy and comfortable to use. Reporting the injury took less than 2 minutes in all cases. 14 injuries (11 acute, 3 overuse) were reported in 9 players. Ankle was most commonly affected (4), followed by shoulder (2), thigh (2), knee (2), pelvis (1), spine (1), head (1) and hand (1). In 6 cases players had the same injury before. Recurrence occurred mostly in ankle (4) despite brace protection (3). Most of injuries did not result in the time loss from game and training participation. Some injuries might have been ignored and not reported by the players.

Conclusions: Based on preliminary use and data SIOMS allows for easy and efficient reporting of both traumatic and overuse injury in handball. Further analysis of data is necessary with special attention to recurrent injuries and possibility of underreporting of injuries by the players.

PERSONALITY BASED SELECTION OF JUNIOR ATHLETES

Miklós Palencsár and Kevin Vermillion

The 3B Personality and Behaviour Based System (“3B System” or “3B”) can define someone’s personality and their decision-making process, and based on this information, can discover their deep-seated motivations. The 3B System has seen great success in the business field for 17 years. Miklos Palencsar, a Hungarian business mentor and founder of 3B, adapted it for use in sports (due in on small part to his addiction to sports). One of 3B’s strengths is the selection and management of youth athletes. For these up-and-coming athletes, it is especially important to establish motivation systems, help manage their personal lives, and groom them for a professional career.

The 3B System is based in part on Marston’s business psychology system. While Marston’s century-old system focuses on a person’s behaviour, the 3B System concentrates more on a person’s original personality, which is far less temporary. The main difference between 3B and other business/sport psychological systems is that 3B can define two personalities: the person’s “original” personality and their “modified” personality; the former defined based on demographic analytics and the latter resulting from a detailed personality test. The difference between the “original” and “modified” personalities reveals a person’s “mask”, the removal of which can pay great dividends during competition.

The 3B System can define two types of masks: the “short-term mask” – which governs behaviour for the next 3-6 months – and the “long-term mask” – which governs behaviour for the next 8-10 years. These data are compiled into a “lifelong personality and behaviour map”. The 3B System creates this map with precision: it uses extensive demographic information to create its personality definitions, with generations divided into four-year periods. Thus, the 3B System understands the minute differences among different age ranges, and can offer precise personality maps starting at age 10.

PRP AND CELL THERAPIES IN LOWER LIMB ORTHOPAEDICS: APPLICATIONS AND EVIDENCE BASED RECOMMENDATIONS

Pawlak M., Sojak D., Owczarski T.

Introduction

In PubMed we can find 10918 articles about PRP. Most of them were published from 2010 - 443 (4,4%) are randomized clinical trials or meta-analyses.

PRP in lower extremity

In tendon and muscle lesions, PRP injection is performed to improve and accelerate healing and recovery process with local application of growing factors: TGF-ß; PDGF-ß, IGF-1, B-FGF. In tendons, TGF-ß increases the expression of procollagen types I and II; PDGF-ß, IGF-1, B-FGF – promotes tendon cell proliferation and tendon healing.

In muscles, these factors improve angiogenesis, proliferation and fusion of myoblasts. They increase muscle regeneration and muscle force.

In cartilage lesions, factors increase chondrocytes phenotype expression and proliferation and upregulate proteoglycan synthesis.

Conclusions

PRP application is safe, cheap and easy procedure which has theoretically great potential in many approaches but still needs to be confirmed with large randomized trials with extended follow-up.

ACHILLES TENDON RECONSTRUCTION WITH SEMITENDINOSUS AND GRACILIS GRAFTS IS A SAFE AND EFFECTIVE METHOD IN TREATING NEGLECTED ACHILLES TENDON RUPTURES THAT ALLOWS FAST RETURN TO PLAY: 2-YEAR FOLLOW-UP AND BIOMECHANICAL RESULTS.

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Achilles tendon ruptures and its chronic disorders are common problem in professional sport nowadays. There are many techniques of Achilles tendon reconstruction, however, there is little evidence that either of them are clearly superior to others.

The aim of this study is to present 2-year follow-up and biomechanical tests results of Achilles tendon reconstruction with semitendinous and gracilis grafts. This is a safe and effective method that allows fast return to play. As part of our laboratory research, we have tested the failure load of the used stitches in reconstruction of the Achilles tendon on the MTS Insight 50kN in cooperation with the Poznan University of Technology.

We present the results of clinical evaluation, magnetic resonance imaging and biomechanical assessment of patients treated with Achilles tendon reconstruction technique using hamstring grafts. We had operated 29 patients with a minimum 1-yaer follow-up with very good results. All professional athletes, including 2 handball players, returned to their previous sport level after the surgery.

DO ARTHROSCOPIC COLLAGEN MATRIX-BASED MENISCUS REPAIR PROCEDURE PREVENT DEGENERATIVE KNEE CHANGES?

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Arthroscopic technique of collagen Matrix-based Meniscus Repair (AMMR) procedure can offer a safe and promising additional tool for surgeons who are willing to make an effort to save the meniscus in the patients otherwise scheduled for meniscal removal. However, it is not well known whether these procedures prevent degenerative joint disease.

A total of 40 subjects reached 5 years follow up. Isolated AMMR procedure were performed on 14 patients, 11 cases with concomitant knee procedures (ACL reconstruction n=9, meniscus suture n=4) were matched. An additional 15 patients were rejected from study due to concomitant cartilage procedure or partial menisectomy. 3.0T MRI was performed to analyze menisci and cartilage quantitatively and qualitatively (Whole-Organ Magnetic Resonance Imaging Score, WORMS). The OA morphologyc changes, such as cartilage lesion, bone attritions, cysts, BMAs, osteophyte, meniscal pathology, synovitis and ligament changes were scored using the WORMS criteria. Each region of a compartment surface received its own score. At each region, the cartilage morphology was scored 0-6. The subarticular BMAs and bone cysts were each scored 0-3. The subchondral bone attrition was scored 0-3. Osteophytes were scored 0-7. The anterior and posterior cruciate ligaments (ACL and PCL) were scored 0 or 1. The medial and lateral collateral ligaments (MCL and LCL) were scored 0, 1 and 2. The anterior horn, posterior horn, and body of the medial and lateral meniscus were each scored and added together to total a score of 0-6. The MRI scans were assessed 6 month and 5 years after surgery. The clinical results were assessed and evaluated by the number of different scoring systems based on patient reported outcomes and clinical findings. The following information were recorded at each assessment point: IKDC 2000 subjective score, IKDC 2000 clinical evaluation score, Lysholm score and Barrett clinical criteria of meniscal healing.

Scores were summarized as means and standard deviations, Inter-observer agreement was based on the exact rating of each feature, not just the presence or absence of each feature, and expressed as intraclass correlation coefficients by treating the data as continuous variables.

Results: At baseline, almost all patients showed MRI-detected OA morphological changes. WORMS quantitative and qualitative scores were slightly progressed from 6,9 in the 6 month FU to 13,1 in the 5 year FU. The clinical results were increased in the IKDC subjective score from 39,51 to 83,04 and 87,98 on average preoperatively, at 2 years FU and 5 years FU respectively. The Lysholm score were increased from 60,44 to 87,61 and 90,94 on average preoperatively, at 2 years FU and 5 years FU respectively. IKDC 2000 clinical and Barrett scores were also improved at 24 months post-surgery. The clinical results were not correlate with WORMS score.

Conclusions: These results suggest, that AMMR procedure may prevent progression of degenerative knee changes.

Keywords: Meniscus regeneration, knee osteoarthritis, WORMS, 3.0T MRI

SPORT-SPECIFIC AQUAWALLGYM TRAINING FOR FASTER RECOVERY

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The Aquawallgym™ is the first mobile underwater gym equipment which combines benefits of water and elastic resistance training. We are engaged to an innovative and secure way of the rehabilitation which ensures faster and more personalized recovery for athletes in cooperation with patients' physicians and physiotherapists.

The Aquawallgym™ Training System turned the equipment into an innovative training method for those who want unique and complete workout in the water. Several special exercises - such as heavy ball, Aquastick, drag socks - ensure diverse, effective and sport-specific training.

The effectiveness of Aquawallgym trainings have been evidenced many times in case of handball players like László Nagy, Máté Lékai, Szandra Szöllősi-Zácsik, Ferenc Illyés etc. After their surgeries they regularly attend in Aquawallgym rehab trainings. Thanks to the successful aquatic rehabilitation their recoveries were much faster than expected and they were able to go back to the field earlier.

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SUCCESS FACTORS IN TEAM SPORT

Gerald Schuhfried

Summary
The „Success Factors Team"(SFTEAM) test set is a diagnostic test package to clarify essential performance and personality dimensions in team sport. It allows users in professional sports to record objective results for the performance and personality dimensions such as attention, cognitive abilities, reaction behavior, and risk behavior. The test set is based on a test battery that has been validated in the scope of teaching events of the University of Vienna

Introduction

In the Vienna Test System the SCHUHFRIED company has for over 60 years been providing high quality and scientifically based tests for use in human resources. The Success Factors Teamsport (SFTEAM) test set is part of the Vienna Test System SPORT (VTS Sport). A test set is a combination of test dimensions that addresses a particular complex assessment issue. A test set relieves you of the task of selecting tests and enables you to be certain of using the right dimensions for the particular assessment situation.

The SFTEAM test set was developed for the VTS SPORT to provide a powerful tool for the assessment of sporting potential in team sport. The test set is based on validation studies that were carried out at the University of Vienna.

Team sport imposes exacting demands on players. These demands are both physical and mental (e.g. Baur, Müller, Hirschmüller, Gruber & Mayer, 2006). However, there is as yet no standard internationally recognized model of the important characteristics of people such as professional footballers (e.g. Reilly, Williams, Nevill & Franks, 2000). Identifying sporting aptitude usually involves assessing a number of characteristics, including:

- physical characteristics (e.g. height, body size)
- physiological characteristics (e.g. aerobic capacity)
- sociological characteristics (e.g. support from the player's social environment)
- psychological characteristics (e.g. attention, concentration)

The characteristics that are taken into account may vary from sport to sport (e.g. Abbott & Collins, 2002). For example, low body weight many be advantageous for gymnastics, while in volleyball good eye-hand coordination may be more important.

Psychological tests are objective measures of psychological characteristics and can therefore make a valuable contribution to an analysis of strengths and weaknesses. However, the validity of the test battery – i.e. its practical value for the user – must have been proven in special studies.

The utility of the test set has been demonstrated in a validation study at the University of Vienna. This has made it possible to draw up an ideal profile that enables teamsport players' weaknesses to be quickly identified and compares their suitability for different positions in the team. The test set is therefore an excellent complement to tests that assess abilities specific to different types of sport.

Methods
The set of tests in SFTEAM is based on a test battery that was administered to 225 players from different playing positions between 2000 and 2008. The ideal profile is based on a regression analysis of the resulting data. The aim was to predict players' performance, as measured by their place in a ranking, from their test results. This analysis was then used to define ideal ranges and relative weights for the test results for the positions of striker, field player and goalkeeper.

The atheletes filled in SIGNAL – focused attention, ZBA – time and movement anticipation, VISGED – short-term memory, STROOP – cognitive interference, TMT-L – information processing speed, DT – reactive stress tolerance, LVT – visual perception, RT – reaction speed, BFSI – individual aspect of sport-related personality.

Development
The test set can be scored in the light of the ideal profiles for the positions of field player, striker or goalkeeper by calculating three fit scores. The fit score, expressed out of a thousand, indicates the extent to which the player's performance matches the relevant ideal profile. The closer the fit score is to 1,000, the closer it corresponds to the ideal profile of a player in that particular team position. The fit score therefore enables you to assess a player's suitability for each of the three positions at a glance. However, it is recommended that the results on each dimension are also analyzed in detail.

Results on the individual dimensions are given as raw scores and percentile ranks. The percentile rank indicates what percentage of a particular comparison group obtained the same or a lower score on the ability or personality characteristic in question. The comparison group is usually a representative sample of the general population. If this is not the case, this is explicitly referred to in the scoring. For example, a percentile rank of PR=76 means that 76% of respondents in the representative norm sample obtain this score or a lower one on this ability or personality trait, and 24% achieve a higher score.

Conclusions
As well as comparing the test results with the norm sample, interpretation should consider the individual profile in order to identify personal strengths and areas for development. As an aid to interpretation a case study will be described and interpreted.

Keywords: attention, cognitive abilities, reaction behavior, risk behavior, Vienna Test System

THE EFFECTS OF THROWING ON DIFFERENT TARGET LOCATIONS UPON THROWING PERFORMANCE IN ELITE FEMALE HANDBALL PLAYERS

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To score goals in handball, accuracy and velocity are the two main factors. A handball goal consists of four corners that are far away from a goalkeeper that increase the chance to score goals. However, it is not known if throwing at these four targets are executed with the same performance (velocity/accuracy). Therefore, the purpose of this study was to investigate the effects of throwing at four different targets locations upon throwing velocity and accuracy in elite female handball players. Thirteen elite female handball players (age 18.2 ± 1.7 yr, height 1.7 ±0.10 meters, body mass 68.1 ±9.6 kg, training experience 9.5 ±3.7 years) were instructed in random order to perform ten throws aiming at one of the four targets located at in each corner (up and down) at 0.25m from the standards of a handball goal from 7m distance. Maximal ball velocity was measured using a Doppler radar gun (Stalker ATS II, Applied Concepts Inc., Plano, Texas) and throwing accuracy was measured (50 Hz.) with a video camera (Sony HDR FX 1000, Tokyo, Japan) at a distance of 15 meters from the goal. Accuracy was measured as: Mean radial error, bivariate variable error, also called consistency and centroid error, also called bias as described by van den Tillaar and Ettema (2003; 2006).

Maximal ball velocity was significantly higher when throwing at the upper ipsilateral corner compared with both target locations on the contralateral side. In addition, ball velocity was higher when throwing at target location on the lower ipsilateral side compared to the upper contralateral side. Of the different accuracy measurements, only bivariate variable error at the upper contralateral side was significantly higher than in the two targets down in the goal. It was concluded that, from the view of the player, the best strategy to score goals from 7m is throwing to the ipsilateral side, since throwing velocity is highest with low inaccuracy.

THE ROLE OF THE RESILIENCE IN HANDBALL TEAMS

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Keywords: handball teams, resilience, psychological intervention, action methods.

It is known that some handball players, like any other top performance athlete, manage stress better than others, coping with pressure and loss during tournaments and afterwards.

After losing a competition or even a game, some handball players manage to bounce back, rapidly, to a previous state of normal functioning; others delay too much in getting over their loss. We focused on the analyses of the post-competition period of time and the development of the handball players in their training and state of mind. For those who cope poorly with loss and defeat in competitions, we consider psychological intervention based on action methods having a main role in their training as the resilience is consider a process not an individual trait.

THE INFLUENCE OF VARIOUS KINDS OF STRENGTH TRAINING ON THE CHANGE OF BALL-THROWING VELOCITY IN ADOLESCENT HANDBALL PLAYERS DURING STARTING PERIOD

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Keywords: handball, strength training, plyometric training, ball-throwing velocity

Introduction: Many specialists maintain that the ability to give the ball high speed during the throw into the goalpost correlates with the effectiveness of offensive actions. It is therefore important to search for measures to develop this skill among advanced players.

Material and methods: The subjects of the research were 28 adult handball players who are first and second Polish division players. They were divided into three groups: a group that does standard training, a group that does additional strength training programme and a group that does additional plyometric training. At the beginning and at the end of the first round of competitions, all the players were tested with a specialist radar to measure the speed of the ball thrown from a standing position, leaning back shot and jump shot.

Results: Over the analyzed period of time, a fall in the speed of thrown ball was observed in the group of players who did additional strength training. It was statistically important in the leaning back shot. However, in the group that did additional plyometric training, an increase in this parameter was observed, which was statistically important in the case of throw from a standing position.

Conclusions: The plyometric training that was used influenced the upper limbs' strength, which was manifested in giving the ball high speed during the throw. The increase was much larger in comparison with the effects of the strength training.

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