



Scientific Conference 2019

5th EHF Scientific Conference “Handball for Life”

21 – 22 November 2019

Cologne, Germany

Documentation



EUROPEAN HANDBALL
FEDERATION



Deutsche
Sporthochschule Köln
German Sport University Cologne



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Handball for Life



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Sporthochschule Köln**
German Sport University Cologne

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FOREWORD



*Michael Wiederer
EHF President*

With the 5th edition of the EHF Scientific Conference in 2019, the European Handball Federation (EHF) celebrates a jubilee of a well-received event. In cooperation with the Union of University Teachers (UUHT) the EHF tries to bring professional, medical, and scientific experts together to share their research, findings, and ideas on the physical and mental welfare of the professional athlete in the areas of performance and training as well as in the technological development of the sports.

The EHF Scientific Conference has been created to give handball experts a forum of communication to share their knowledge, their theoretical as well as their practical approaches. This conference emphasises the importance of scientific perspectives within handball as everybody in the handball family strives to broaden his or her competence.

The first conference in 2011 focused on sports training and medicine; in 2013 the emphasis was on women's handball and knee injuries. At the 2015 convention, we were enthused to host several presentations on the medical aspects of the handball sports. The 2017 symposium was aiming at the player's mental, physical and social health, with a special focus on equipment issues. Now, at the 2019 conference, the time has come to look at handball as a comprehensive sport as it reaches from early stages of childhood to maturity. "Handball for Life" represents an approach to accompany players of all ages during their Handball journey. In the upcoming years our emphasis will be laid at this area. Is there a better way to start than with a Scientific Conference?

The EHF is grateful to host the anniversary at the German Sport University Cologne since it is known as a flagship within the European Sports Science Community and an important EHF Partner for offering educational services such as the European Handball Manager Certificate programme. With almost 50 presentations this year's edition shows the enormous engagement of handball enthusiasts to scientifically explore the game and its environment. Moreover, those academic approaches aim at the advancement of handball within a rapid changing world of sports.

I very sincerely thank the members of the 2019 EHF Scientific Conference Organising Committee and the members of the EHF Scientific Network for administering this special anniversary which was also made possible with the engagement of the EHF Competence Academy & Network. I hope that the presenters and participants of the 5th EHF Scientific Conference are inspired to further engage their endeavours to enlarge the horizon of the handball world.

Michael Wiederer
EHF President

Table of Contents

Keynotes

Póvoas (POR) “The handball 4 health project – implementation, dissemination and research”	8
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Oral Presentations

Carneiro et al. (ITA) “Physiological demands of 5v5 indoor and outdoor recreational team handball matches for inactive over 60-year-old men”	12
Dias Estriga (POR) “The effect of resin and ball size on the throwing velocity”	15
Fasold; Gehrler (GER) “Beach handball – from the grassroots”	19
Gheorghe; Mereuta (ROU) “The impact of a top player injury on Romanian National handball team performance at the France EHF EURO 2018”	24
Gillard; Romenskaya (RUS) “Differences in attention attributes for female handball players”	31
Gillard (RUS) “Features injuries handball players 18-20 years old in competition”	37
Gonzaga; Sequeira (POR) “Coaches’ emotional skills and interpersonal behaviours in sports coaching”	43
Hermassi et al. (TUN) “Effects of training specificity into influencing agility and sprint performance of team handball players”	48
Karcher et al. (FRA) “Determinants of shooting velocity in elite team handball players”	54
Nicklas et al. (GER) “Effects of blocking on defense performance in beach handball”	59
Ökros (HUN) “Load parameters associated with Qatch matches using microsensor technology”	65
Pereira et al. (POR) “Recreational team handball has positive effects on bone health, body composition and physical fitness of inactive postmenopausal women”	71
Sobreiro et al. (POR) “An approach to the phenomenon of handball player’s retention in Portuguese context”	75
Sequeira; Erichsen (POR) “E-Handball: Technology helps development“	81
Sequeira; Lopes (POR) “E-Sports: Handball New Challenge”	86
Slowinski (POL) “The referee’s age and experience versus the accuracy of handball referee decisions at various levels of competition”	92
Souli; Gillard (RUS) “Peculiarities of motivation in the activity of professional handball players”	99
Wilhelm et al. (GER) “Fouls in women’s team handball – the effect of a permitted foul on defense performance”	106

Poster Presentations

Dias Estriga; Ferreira (POR) “Implications of a linear force-velocity relation on complex movements. A preliminary study with throwing”	115
Fukuda et al. (JPN) “Effect of ankle taping on knee and hip joint angles during jump landing tasks”	119
Gillard; Boussaha (RUS) “Conflictometric analysis of interpersonal relations in women’s handball team”	125
Hodic (CRO) “Physiotherapy and rehabilitation in professional sports”	132
Hodic (CRO) “The most common injuries in team sports and their early rehabilitation with the use of orthopaedic sport supports”	135
Ichimura et al. (JPN) “Development of statistical data index for evaluating the tactical aspects of attack and defense in handball”	140
Ito et al. (JPN) “Kinematic analysis of throwing for handball player the difference between using sticking tape and the sticking gel”	147
Jelicic (CRO) “Injury, Prevention and recovery – psychological background and approach”	154
Lindenthal (GER) “Shot frequency and success rate of various types of throws from backcourt positions”	157
Mohoric; Sibila; Bon (SLO) “Motor and morphological differences between young female handball players from three age groups”	162
Moriguchi et al. (JPN) “Electroacupuncture (EA) treatment for top athletes in Japan a case of treatment of strained calf muscle in handball player”	169
Redlich; Fasold (GER) “What makes you win? – The perception of handball specific match situations”	175
Seipp et al. (GER) “Application of one-handed catches in elite men’s team handball”	181
Skarbalius (LAT) “Quantification of monotony, weekly load and strain an entire competitive period in semi-professional female handball”	187
Suzuki et al. (JPN) “The effect of plyometric training on anterior cruciate ligament injury prevention and leg muscle strength in female junior handball players”	193
Further topics presented at the Scientific Conference (Abstracts)	199
List of e-mail addresses	232

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”
- *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.

KEYNOTES

THE HANDBALL 4 HEALTH PROJECT – IMPLEMENTATION, DISSEMINATION AND RESEARCH

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Summary

The Handball4Health main purposes are to describe the physical and physiological demands of recreational team handball in diverse settings, to determine the feasibility and the health, physical fitness and well-being effects of team handball practice in different populations, with and without previous experience with the sport, and to promote, disseminate and implement this sport as a means to contribute to prevent, treat and to rehabilitate from lifestyle-related diseases.

Keywords: recreational team handball, health and physical fitness effects, barriers, contextual settings.

Introduction

This year, the EHF scientific conference puts a “special emphasis on grassroots handball to underline that interest in sport should be initiated at a very young age and does not necessarily need to end at a higher age”. Indeed, team handball in its recreational version can be used as an effective exercise mode to improve participants’ health, physical fitness and well-being status in both young and older populations, regardless of their experience with the sport, showing high adherence (Hornstrup, Lowenstein, et al., 2019; Hornstrup et al., 2018; Póvoas et al., 2018). This is aligned with the current World Health Organization (WHO) Global Action Plan, aiming at reducing physical inactivity and the United Nations Sustainable Development Goals (2030 Agenda), namely Goal 3 – “To ensure healthy lives and promote well-being for all at all ages”.

It responds to the WHO call for innovative exercise modes that could meet the population interests. This because, physical inactivity is the primary cause of most chronic diseases (Booth, Roberts, & Laye, 2012), being responsible for 5.3 million deaths per year worldwide (Lee et al., 2012) and considered one of the most important public health problems of the 21st century (Blair, 2009). Nevertheless, a third of the adults worldwide do not meet the recommended guidelines for physical activity (Hallal et al., 2012). Hence, from a public health perspective it is mandatory to identify novel exercise modes, besides the traditional ones such as aerobic, resistance or combined training, that can meet the physical activity guidelines, and simultaneously, keep the participants motivated, and thus assuring long-term adherence.

Team handball has been reported to be played by ~19 million worldwide (Karcher & Buchheit, 2014), so the potential for generalization is appealing not only for former team handball trained players, but also for fans worldwide. Therefore, the aims of the Handball4Health are to describe the physical and physiological demands of recreational team handball in diverse settings, to determine the feasibility and the health, physical fitness and well-being effects of team handball practice in different populations, with and without previous experience with the sport, and to

promote, disseminate and implement this sport as a means to contribute to prevent, treat and to rehabilitate from lifestyle-related diseases.

Development

The Handball4Health project, is a multidisciplinary, international, innovative initiative supported by the European, Portuguese and Danish Handball Federations and several other institutions, such as Universities, Research Centers and other stakeholders.

The research done so far has shown that recreational team handball physiological demands are in line with those found to induce positive effects on aerobic, anaerobic, and musculoskeletal fitness in inactive adults of both sexes (Hornstrup, Lowenstein, et al., 2019; Hornstrup et al., 2018; Póvoas, Castagna, et al., 2017) and preliminary results show the same trend for older populations (Póvoas, Lopes, et al., 2017). This, regardless of the participants' previous experience with the sport. It is an accessible, high-adherence and high-attendance exercise mode. Recreational team handball practice has a high aerobic component (HRs~80%HRmax) that associated with multiple actions performed at high intensity, load the anaerobic metabolism and stress the musculoskeletal system. In line with this, cardiovascular, metabolic, body composition and well-being positive alterations were shown in adults of both sexes (Hornstrup, Lowenstein, et al., 2019; Hornstrup et al., 2018; Póvoas et al., 2018), and preliminary data show that that it is also the case for older populations (Póvoas, Lopes, et al., 2017).

Taking into account the encouraging remarkable positive effects of recreational team handball practice on health, physical fitness and wellness variables of apparently health populations, the future aims of the Handball4Health project are to further enhance the current knowledge on the effects of recreational team handball practice in clinical populations. In fact, small-sided team handball training has already shown to enhance cardiorespiratory fitness and body composition of overweight premenopausal women (Hornstrup, Póvoas, et al., 2019). Consequently, novel studies in this area are being planned.

The results from the Handball4Health project have already been disseminated in scientific papers, and presented in several scientific conferences, but also at community level (e.g., City Halls, Associations of Local Health Centers, Knowledge Dissemination Associations) and at several European Handball Federations with the support of the European Handball Federation, and several collaborations have been established with the media through TV and social media coverage.

Implementation initiatives of the Handball4Health project are now being performed at national and international level and many more countries are welcome to be on board. In this regard, barriers of implementation, settings, human resources training, recommended game formats, materials and rules will be covered in this conference.

Conclusions

The collected scientific and practical evidence on the beneficial health, physical fitness and well-being effects of recreational team handball, suggests its implementation as a non-pharmacological medicine to prevent and treat from lifestyle-related diseases in different populations. Future large-scale studies addressing the effects of recreational team handball practice across ages and sexes are necessary.

ORAL PRESENTATIONS

PHYSIOLOGICAL DEMANDS OF 5V5 INDOOR AND OUTDOOR RECREATIONAL TEAM HANDBALL MATCHES FOR INACTIVE OVER 60-YEAR-OLD MEN

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Summary

This study analyses the physiological demands of recreational team handball, played as 5v5 matches, in indoor and outdoor team handball courts for over 60-year-old inactive men with no prior experience with this sport. The results show that team handball is an intermittent high-intensity and fun exercise mode with physiological demands expected to induce positive effects on cardiovascular health in this population, regardless being played in indoor or outdoor courts.

Keywords: Recreational team handball; cardiovascular strain; heart rate.

Introduction

Physical inactivity is the primary cause of most chronic diseases, including cardiovascular, type 2 diabetes, osteoporosis, obesity, and depression (1). It has been shown to be responsible for 5.3 million deaths per year worldwide (2) and considered one of the most important public health problems of the 21st century (3). Nonetheless, a third of the adults worldwide do not meet the recommended guidelines for physical activity (4) and Portugal is one of the countries with the lowest percentage of the population engaging regularly in exercise and sport (5). Low cardiorespiratory fitness has been reported to be a significant predictor of all-cause mortality (6). However, exercise and physical activity primarily prevent, or delay, several chronic conditions (1, 6) and exercise, is considered effective in increasing cardiorespiratory fitness (6).

Middle-aged and older men typically show excessive body weight, due to increased body fat and decreased muscle mass (7), and compared to women, show less healthier behaviours and higher rates of most chronic diseases (e.g., hypertension and diabetes) (8), less physiological and functional status (9), and have higher healthcare costs (10). Additionally, men are harder to engage in lifestyle changes (8). Considering that lack of motivation to exercise is the major cause of sedentary behaviour in adulthood (5), it becomes imperative to investigate new types of exercise that result in health and physical fitness improvements and that are simultaneously, motivating, thus assuring long-term adherence to exercise.

Recreational team handball is a high-demanding intermittent exercise mode that primarily uses the aerobic metabolism, interspersed by high-intensity actions that greatly tax the anaerobic metabolism due to numerous high-intensity displacements and actions that occur throughout the game (11) that greatly load the muscles and bones. It has shown to be effective in improving

physical fitness and cardiometabolic health in former adult male team handball players (12) and in young adult men (13) and women (14) with no experience with the sport. Nevertheless, information on the physiological demands of this exercise mode is lacking for older populations, as well as, for the demands of playing in indoor and outdoor settings. Therefore, the aim of this study is to analyze the physiological demands of recreational team handball, played as 5v5 matches, in indoor and outdoor team handball courts for over 60-year-old inactive men, with no prior experience with this sport.

Methods

Twenty-two participants (68.0 ± 3.0 years; height 168.1 ± 5.3 cm; body mass 79.0 ± 10.6 kg; fat mass $27.8 \pm 5.9\%$) performed two indoor and two outdoor, 45-min, 5v5 recreational team handball matches. The outdoor matches were held under neutral temperature ($20\text{--}22^\circ\text{C}$) and humidity conditions (50-60%) and the pitch size was 20x40m in both the indoor and outdoor courts, resulting in 80 m^2 per player. The participants had no previous experience with this sport.

The internal load (heart rate (HR), blood lactate and rating of perception exertion (RPE)) variables and fun level were analyzed during 4 training sessions (2 indoor and 2 outdoor) from 5v5 recreational team handball matches. The training sessions comprised a 15-min standardized warm-up, consisting of running, coordination, strength, flexibility and balance exercises and 3 15-min periods of recreational team handball interspersed by 2-min breaks. At every 2-min in each period, one different participant playing in a field position was instructed to change his position with the goalkeeper. There were no players' substitutions during the matches and only the participants that had performed all the 3 15-min periods were analyzed. All the participants were informed about the study purposes, risks and benefits and signed a written informed consent according the Declaration of Helsinki and ethical approval was provided by the local Institutional Review Board.

Anthropometric data such as body weight (0.01 kg), fat mass and height were measured by a digital scale (Tanita Inner Scan BC 532, Tokyo, Japan) and a portable stadiometer (Seca 213, Hamburg, Germany), respectively, according to standardized protocols (15).

Exercise intensity was assessed by HR monitors (Firstbeat Technologies Ltd., version 4.5.0.2, Jyväskylä, Finland), and were registered 71 HR records (35 indoor and 36 outdoor) from 22 players. The defined HR zones were ≤ 50 , 51–60, 61–70, 71–80, 81–90, and 91–100% of maximal HR (HR_{max}). HR_{max} was considered as the highest HR value resulting from all testing conditions (physical tests or matches) using short-range telemetry (Firstbeat Technologies Ltd., version 4.5.0.2, Jyväskylä, Finland). RPE (16) was recorded at the end of all training sessions. Also, capillary blood samples ($30\ \mu\text{L}$) were drawn from the right earlobe to determinate blood lactate concentrations (114 records, 42 indoor and 72 outdoor from 22 players), at the end of the first and third periods of the matches. For this analysis, a portable electroenzymatic lactate device analyzer (Lactate Pro 2 LT-1730, Arkray, Amesterdam, The Netherlands) was used. A visual analogic scale (0-10) was used to quantify the levels of fun at the end of all training sessions (17).

Statistics

Changes between indoor and outdoor matches variables were assessed by Student's paired t-test. Statistical Package for the Social Sciences (SPSS Inc, version 25.0) was used for the analyses.

Statistical significance was set at $P \leq 0.05$. Results are presented as means \pm standard deviations (SD).

Results

Results (Table 1) show that the indoor and outdoor mean HRs were 77 ± 5 and $76 \pm 4\%HR_{max}$ ($P=0.073$), peak values were 86 ± 6 and $85 \pm 5\%HR_{max}$ ($P=0.092$), and HR was $>80\%HR_{max}$ for 44 ± 22 and $35 \pm 23\%$ ($P=0.116$) of total match duration, respectively. RPE was 7.1 ± 2.4 and 6.5 ± 2.4 (AU, 0-10) ($P=0.052$), and fun was 9.1 ± 0.7 and 9.1 ± 1.1 (AU, 0-10) ($P=0.738$), respectively. Mean blood lactate values were 4.1 ± 1.7 (1.7-8.1) and 3.7 ± 1.6 (1.4-6.1) mM ($P=0.353$) for the indoor and outdoor matches, and peak blood lactate values were 4.7 ± 1.8 (1.7-8.3) and 4.6 ± 2 (1.4-7.3) mM ($P=0.802$), respectively. No significant differences were shown between the indoor and outdoor matches in the analyzed variables.

Table 1. Internal load variables and fun results (means \pm SD) during the indoor and outdoor 5v5 recreational team handball matches.

Variable	Indoor	Outdoor	P
Mean Heart Rate (%HRmax)	77 ± 5	76 ± 4	0.073
Peak Heart Rate (%HRmax)	86 ± 6	85 ± 5	0.092
Heart Rate $> 80\%$ HRmax (%)	44 ± 22	35 ± 23	0.116
Rating of perception exertion (AU, 0-10)	7.1 ± 2.4	6.5 ± 2.4	0.052
Fun (AU, 0-10)	9.1 ± 0.7	9.1 ± 1.1	0.738
Mean blood lactate (mM)	4.1 ± 1.7	3.7 ± 1.6	0.353
Peak blood lactate (mM)	4.7 ± 1.8	4.6 ± 2	0.802

Conclusions

Recreational team handball, played as 5v5, is an intermittent high-intensity fun exercise mode with physiological demands expected to induce positive effects on cardiovascular health of middle-aged and older men with no experience with this sport, regardless being played in indoor or outdoor team handball courts.

THE EFFECT OF RESIN AND BALL SIZE ON THE THROWING VELOCITY

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Summary

This research comprised two preliminary studies about the effect of resin and ball size on the throwing velocity. Our preliminary results suggest that for senior male players, banning the resin usage should be accompanied by a downsize of the ball if similar shooting velocities – and general game characteristics - are to be preserved. The resin usage amounts to an effect on speed (a gain) of about 9% when shooting with the ball size 3.

Introduction

The International Handball Federation announced the intention of prohibiting the use of resin in handball, addressing the reluctance of many administrators of indoor facilities to its usage. Therefore, this organism approved new technical requirements regarding the ball's size and characteristics according to players' age category, where the ball standard sizes (1, 2 and 3) without resin were downsized (smaller and lighter). Both official resin-free balls 2 and 3 were 2.5 cm (on average) downsized. For more details see the table 1.

Table 1. Technical specifications for handballs with and without resin, according to the Rule 3 of the Rules of the Game, IHF Ball Regulations, amended in July 2019.

Ball's size - With resin				
	Circumference (cm)	Weight (g)	Men	Women
IHF Size 1	50-52cm	290-330g	Aged 8 to 12	Aged 8 to 14
IHF Size 2	54-56cm	325-375g	Aged 12 to 16	Aged 14 and older
IHF Size 3	58-60cm	425-475g	Aged 16 and older	
Ball's size - Without resin				
	Circumference (cm)	Weight (g)	Men	Women
IHF Size 1	49-51cm	290-315g	Aged 8 to 12	Aged 8 to 14
IHF Size 2	51.5-53.5cm	300-325g	Aged 12 to 16	Aged 14 and older
IHF Size 3	55.5-57.5cm	400-425g	Aged 16 and older	

Much of the debate and controversy is about how the resin prohibition will affect players' shooting skills, mainly the throwing speed and tricky shots from narrow shooting-angles, such as the spin shots. As resin facilitates ball gripping/manipulation and shooting mastery, a lot of effort has been placed in finding a technical solution for the problem.

In all levels of learning or performance, the ability of grasping the ball is critical to successful play. Some authors have already studied what they called "ball coverage index" among ages and sexes, with a sample of 1612 handball players (mostly Spanish), and concluded that, in the case of females in all categories over 14 years of age, the official ball sizes should be downsized and the opposite was found in the males (Oliver & Sosa, 2013). But, they did not consider the resin effect.

The main objective of this study is to exploit the effect of the resin in ball throwing velocity in the adult male category.

Methods

Ten adult handball players (23.8 ± 0.3 years; 183.2 ± 7.0 cm; 87.9 ± 6.3 kg) from the same team competing in the "Senior Men's Second National Division" participated in this study. All the players included in the study had more than 10 years of regular handball practice and were training four times per week, for about 90 min. per session. The inclusion criteria used were being free of injuries at the time of the study and free of shoulder pain/injuries during the previous two months. Before the throwing speed assessment, all players performed the standard warm-up with the team with a duration of about 20 min..

The study was carried out at the beginning of each training session at the end of the pre-season (September 2019). Six sessions were organized according to the team coach's convenience. The protocol uses first-hand official ball's size #2 (with 55cm circumference) and #3 (with 59cm circumference), and each player performed two testing sessions of about 35 min. each (one with resin and the other without resin). The players performed fifteen 7-metre throws towards an empty goal with each ball size, in a random order. The players were instructed to use a standard overhand throwing technique, from standing still position (set throw), and to always shoot with maximum speed towards the middle of the goal. The participants were divided into two groups; while one group first used the protocol with resin, the other one used the opposite, then, they repeated the protocol exchanging the throwing conditions (with/without resin). There were several days (a minimum of 48 hours) between the testing sessions. The ball speed was measured with a handheld radar gun, positioned behind the goal and at its middle.

Development

The median throwing velocities with both ball sizes and with/without resin usage is presented in the table 2. The resin usage amounts to an effect on speed (a gain) of about 6% with the ball size 2 and 9% with the ball size 3. The Paired *t*-Test doesn't reject the hypothesis that the shooting speed of a size 2 ball without resin is equal to that of a size 3 ball with resin.

Table 2. Measured ball velocity in a standard 7-meter throwing situation.

Unit=km/h	Ball size 2		Ball size 3		Overall
	Median	<i>IQR</i>	Median	<i>IQR</i>	Median
Without resin	86.8	2.4	78.3	3.5	85.8
With resin	92.0	2.5	85.5	3.4	89.8

When using resin, the velocities decreased during the testing session, which suggests a fatigue effect (Table 3). But, in the protocol without resin, the velocities slightly increased, what might be explained with a possible adaptation or motor learning effect during the testing protocol. The Paired *t*-Test showed that the changes in velocity during the sequence of throws with and without resin differed significantly ($p < 0.0001$). A great fatigue effect was observed (decrease of about 8% in speed) in the throwing velocities when using resin. In the figures 1 and 2, two examples are presented. Our results indicate that there is need for studying the learning effect when throwing without resin.

Table 3. Evolution of the shooting velocity of the players during the testing session

(km/h)/repetition	Ball size 2	Ball size 3
Without resin	0.9%	2.7%
With resin	-7.8%	-8.2%

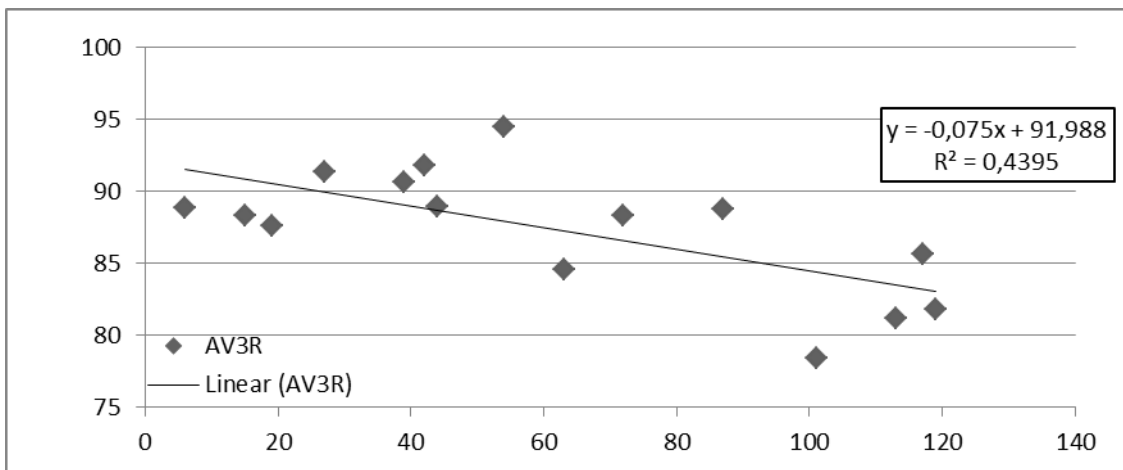


Figure 1 - Sample of a throwing velocities sequence of a player with ball size 3, with the usage of resin

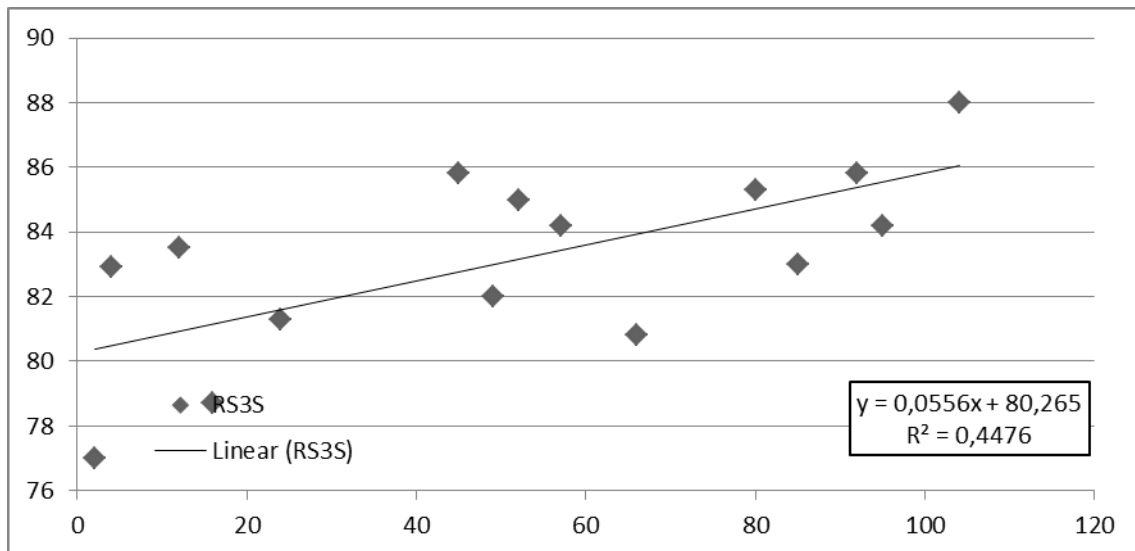


Figure 2 - Sample of a throwing velocities sequence of a player with ball size 3 and without using resin

Conclusions

Our preliminary results suggest that, for adults, banning the resin usage should be accompanied by a downsize of the ball if similar shooting velocities – and general game characteristics - are to be preserved. The resin usage amounts to an effect on speed (a gain) of about 9% in senior male payers. More biomechanical and performance studies are needed with other handball populations, including women and players with different stages of maturation or ages.

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Beach Handball - From the Grassroots

Frowin Fasold (German Sport University Cologne, Germany), Alexander Gehrer (EHF Lecturer, Germany)

Summary

The manuscript presents a brief overview of the short history of this inspiring team sport and shows the advantages of playing beach handball with kids. Subsequently, two different games, designed for kids under 10 and under 12 years of age respectively, are presented. The rules of these two games have been developed based on social-psychological theories to ensure maximum enjoyment and to familiarize the kids with some major topics of the game of beach handball.

Keywords: youth handball, beach handball, sports enjoyment, game rules for kids

Introduction

The history of beach handball began in the early 1990s with a member of the C.O.N.I. (the Italian Olympic Committee), Professor Briani, who, based on the experience with beach volleyball, came up with the idea of working on a new sport which on the one hand would attract summer holiday-makers and on the other hand become a valuable means of promoting the classic sport of handball.

The first beach handball tournament worldwide took place at the beach of San Antonio in Ponza (ITA) in July 1992. Within the same year (1992), Gianni Buttarelli and Franco Schiano founded the “Comitato Organizzatore Handball Beach” (COHB) in Italy, which became the first organized association representing beach handball worldwide.

The international interest in beach handball grew permanently. Beach handball was officially recognized by the International Handball Federation (IHF) in May 1994, and internationally valid rules for beach handball were established during the IHF congress in September 1994 in Haarlem (NL).

In the year 2000 the first European Beach Handball Championships were organized by the European Handball Federation (EHF) in Gaeta near Rome (ITA). In 2019 the 11th Beach Handball European Championships were held in Stare Jablonki (POL), with 40 competing teams. Furthermore, Youth European Championships were introduced in 2008.

At the World Games 2001 in Akita (JPN) beach handball, for the first time, constituted an invitational sport. Since then, it was included in the program of The World Games four more times (i.e., 2005 in Duisburg, 2009 in KaoHsiung, 2013 in Cali, and 2017 in Breslaw), while since 2009 it was included as an official sport.

The first Beach Handball World Championships took place in El Gouna (EGY) in 2004; in 2020 the 9th Beach Handball World Championships will be held in Pescara (ITA).

In 2018 beach handball made its debut in the Youth Olympic Games in Buenos Aires (ARG). With regard to the numbers of spectators beach handball was one of the top sports of this event; on the final day more than 2000 spectators had to watch the matches in the arena; also, IOC President Thomas Bach was impressed by the atmosphere.

Within 25 years beach handball became an internationally recognized sports game. The next step in its development will now be its inclusion in the Summer Olympic Games.

Lifestyle and Advantages of Beach Handball

Beach handball is constantly gaining popularity, not least because especially young people can live out their lifestyle values in this sports game (such as fun, sun, action, acrobatic elements, excitement until the end of the game, self fulfilment). Moreover, the advantages of this game, in particular for kids, are obvious:

Due to the material of the ground (sand) the risk for injuries caused by falling, jumping or diving for the ball is much lower and the stimulating nature of sand is very high.

Since bouncing the ball in beach handball is not possible, the ball must be passed very often. Thus, the ability of orientation will be taught.

Due to its material, the ball is easy to grasp for every kid and in the defense (or as goalkeeper) the ball does not hurt.

The goalkeeper has a special role and is not confined to the goal area.

Due to the permanent 4:3 situation in attack, one player should always be unmarked; therefore, it becomes much easier to score goals and the success of scoring is guaranteed.

Because “spectacular goals” are rewarded with extra points, kids start to experiment and to find their own style.

Enjoyment of the Game and the Major Topics to Learn

While keeping the advantages of playing beach handball in mind, the actual rules of the game (for adults) could overstrain kids for several reasons. An adapted framework of rules should not only constitute a less complex version of the adults’ game rules, it should in particular also foster the kids’ sports enjoyment. The level of perceived sports enjoyment is directly connected to the strength of sport participation. In the best case, the enjoyment of playing the game at a young age leads to life-long beach handball participation. Therefore, the focus should always be on the kids, and a game should be developed, which foremost promotes the kids’ enjoyment of the sport, and in second place, teaches the kids about the major topics of beach handball. Thus, every implemented rule should be based on five parameters, which are directly connected to motivation and enjoyment:

The opportunity of perceiving one’s own competencies.

The execution of unknown and special movements.

The perception of social support and interaction.

The feeling of physical activity, in particular the feeling of changes in intensity of physical activity.

Perceived autonomy concerning one’s own behavior.

Playing a team sports on sand, some of these five usually become effective, but rather, the implemented rules should ensure...

...that a high amount of actions is guaranteed, so that every participating kid experience success (and make mistakes) and to perceive his/her individual competencies. Playing in small groups (4 against 4, 3 against 3) could ensure a high amount of actions (in the offence and the defence) because most of the time all players will be involved. Frequent substitutions ensure that also the substitution players are given opportunities to perceive their own competencies. Playing with short sets, shootouts, and tournament modes enhances the probability that every participating kid has the chance of positively perceiving of own his/her own competencies, and those of his/her teammates, by winning (even just one set).

...that unknown, special, surprising, and creative actions are necessary for playing the game. The variable and uneven, sandy underground calls for special, creative, and unpredictable solutions concerning movement and behavior. Further, using balls which are easy to grip and handle makes creative actions possible for every participating kid. The point scoring system, rewarding creative goals with two points, also contributes to more sport enjoyment.

...that all players support each other and interact on the field (and in the substitution areas). The frequent substitutions and the fast-paced nature of the game without strict tactical regulations require high levels of social interaction as well as social support. The shootout situation represents a very special and unique situation in which the necessity for social support is particularly obvious.

...that there are frequent alternations between short-term, high-intensity physical activity and rest. Playing on sand with frequent substitutions ensures high-intensity actions, and therefore, also breaks for rest.

...that kids can act autonomously within in the game. The point-scoring system gives every participating kid the chance to behave autonomously by deciding between easy scoring attempts worth one point and more difficult attempts worth two points.

As mentioned above, in addition to these parameters of enjoyment, kids should also be introduced to the following major topics of beach handball:

Defending without body-contact, just attacking the ball.

Playing creatively and ingeniously.

Preparing for the complex actions of spin shots and inflights.

Substitutions in blocks, after scoring or loosing possession of the ball.

Becoming familiar with the point-scoring-system.

Becoming familiar with the set-, and shootout-system.

Game Rules for Kids

Below, two different games are proposed, taking into account the idea of actual game of beach handball (scoring points + reconquering the ball as a team), and the parameters and necessary rules to promote sport enjoyment and the major topics to learn. These two games also take into account the kids skills and abilities considering their actual stages of development.

Mini Beach Handball for Kids Under 10 Years

Reduced field sizes are possible, while especially reduced goal-areas are necessary (e.g. 12x8m, two goal-areas of 5m). Every team consists of eight players, divided into two blocks. While one block of four players acts on the field the other block of four players is positioned on the sideline. Substitutions are possible along the whole sideline, but according to the rules of the adult's game each team can only substitute along one side of the field.

All players of one team wear jerseys of the same color. One player at a time can enter the own goal area and act as the goalkeeper, yet the goalkeeper must exit the goal area after gaining possession of the ball.

If one team scores a goal, all four players of this team must be substituted as a block. If a team consists of only seven players, one of the players can stay on the field (this holds true for both teams). In addition, after a block's third unsuccessful attack its substitution is also allowed.

The opposing team is allowed to continue the game immediately by a throw-off or a direct coast-to-coast attempt after a goal has been scored against them.

The game is played with a grippy methodic ball (street handball). One ball (each) should be placed behind each goal; one more ball is used to start the game.

The point-scoring-system is used. Every goal judged as spectacular by the referees counts two points. Examples of these shots are:

spin shots, 360° spin and takeoff with both legs is not necessary,

inflight, all attempts, as well as hitting the ball with arms, fist, head,

frog-jump-throws, takeoff with both legs,

further spectacular attempts, e.g. throws behind the back, between the legs,

5m penalty goals,

and coast-to-coast goals.

Every game consists of two sets (of 5 min each) and a shootout (including all players). If one team consists of more players than the other (e.g., team A consists of 9 players and team B of 8 players), one player of the latter team (in this case team B) is allowed to make a second attempt.

During the shootout both goalkeepers are positioned in their own goal area (they are not confined to the goal line but are not allowed to leave their own goal area). The court player stands in the playing area (at the intersection of his/her goal area line and the sideline) and plays the ball to his goalkeeper. The goalkeeper must now pass the ball back to the court player, who is running towards the opponent's goal. The court player must catch the ball and try to score a goal without any rule violations; however, before the shot, the ball is allowed to touch the sand one time (either before or after receiving the pass from the goalkeeper).

Ultimate Beach Handball for Kids Under 12 Years

At this age the normal field size is recommended. Every team consists of eight players, divided into two blocks. While one block of four players acts on the field the other block of four players is positioned in the substitution area. Substitutions are possible along the whole

substitution area, but according the rules of the adult's game each team can only substitute along one side of the field.

Two players of every team wear a different jersey color than their teammates (one stands on the court and one waits in the substitution area). These players acts as goalkeeper and (!) as specialist. After gaining possession of the ball, the defending goalkeeper must exit the goal area and act as specialist in the offence.

If one team scores a goal or loses the ball, all four players of this team must be substituted as a block (including the specialist). The opposing team is allowed to continue the game immediately after a goal has been scored against them or after gaining possession of the ball. If one team consists of only seven players, one of the players (other than the specialists) can stay on the field (this holds true for both teams).

The game is played with a beach handball size 0. One ball (each) should be placed behind each goal; one more ball is used to start the game.

The point-scoring-system is used; the following actions count for two points:

spin shots, takeoff with two legs is necessary, 360° spin is not necessary,

inflight, the ball must not be caught before throwing,

goalkeeper goals, from their own goal area,

goals of specialists,

and 6m penalty goals.

Every game consists of two sets (of 7 min each) and a shootout (including all players). If one team consists of more players than the other (e.g., team A consists of 9 players and team B of 8 players), one player of the latter team (in this case team B) is allowed to make a second attempt.

During the shootout both goalkeepers are positioned in their own goal area (they are not confined to their goal line but are not allowed to leave their own goal area). The court player stands in the playing area (at the intersection of his/her goal area line and the sideline) and plays the ball to his goalkeeper. The goalkeeper must now pass the ball back to the court player, who is running towards the opponent's goal. During this pass the ball is not allowed to touch the sand. The court player must catch the ball and try to score a goal without any rule violations.

Additional Rules valid for Mini- and Ultimate Beach Handball

If one team wins both sets and the shootout, they win 2:0. If one team wins one set and the shootout, they win 2:1. If one team wins both sets and loses the shootout, they win 2:1.

All other rules concerning body-contact, substitutions, playing the ball, steps, etc., are in line with the rules of beach handball for adults.

THE IMPACT OF A TOP PLAYER INJURY ON ROMANIAN NATIONAL HANDBALL TEAM PERFORMANCE AT THE FRANCE EHF EURO 2018

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Abstract

The aim of this study is that of analyzing whether the injury suffered by the most valuable player of the Romanian National Team, in a key moment of the competition influenced the team’s subsequent performance. Team efficiency has been analyzed, based on data provided by the European Handball Federation’s website, as well as on data collected by the author by re-watching and reviewing the matches.

Keywords: Handball; women; injury; analysis; national team.

Introduction

Handball game is characterized by different typical and atypical situations in the game, therefore, the need for an objective registration of certain situations in the game and the parameters of situational effectiveness of each player in competitive conditions (Vuleta, D. et al., 2003). In the modern sports, structure parameters of competitive activities are the basis for comparative analysis of athletes and the entire team (Vuleta, D. et al., 2015).

Being a complex sport game determined by the individual performance of each player, as well as by tactical components and team interaction (Wagner, H., et al., 2014), the handball game is also strongly influenced by social/mental factors within and outside the team. (Michalsik, L., B., 2018).

Injuries are a serious problem in many sports, and handball is no exception. As it is a tough, contact sport, handball entails actions such as sprinting, stopping, changing direction, jumping and landing, turnings, accelerating and decelerating, etc. (Karcher, C., & Buchheit, M., 2014). An injury can occur at the most inappropriate moments and can keep an athlete away from competition from a couple of minutes up to several months, depending on the nature and gravity of the injury. The risk of injury during competitions is ten times higher than during training, being in close connection with the players’ age, health, fitness condition and training level (Seil, R. et al, 1998). Not only do the effects of a serious injury cause pain and frustration to a player, but they can also jeopardize the team’s overall performance (Vărzaru, C. et al., 2015).

The topic of this paper is the impact of a top player’s injury on the ulterior performance of her team, during a major competition. As far as we know, this topic has not been approached yet. However, Vărzaru, C. et al., (2018) analysed the opening offense systems of the Romanian National Handball Team at the EHF 2018 held in France, concluding that “the main purpose of almost all this action was to bring a back player, especially Cristina Neagu, in the middle of the field, because of her ability in taking the right decision: to shoot from long distance, to play 1:1 with the direct defender, or 2:2 situation, working together with the line player, mostly Crina Pintea.”

There are some other papers (Ferragut, C. et al., 2018; Noustos, S., K. et al. 2018; Saavedra, J. M. et al., 2018; Pic, M., 2018) that debate on the factors that influence sports performance.

As it goes through a transition period, the Romanian National Handball Team was made up, for France EHF championship, of 17 players. Six new players were selected, out of whom, three for the first time in a major senior competition. Afterwards, as a result of the injury suffered by a top player, during the match against Hungary, Bianca Maria Bazaliu also joined the team for the games in the semifinal and the small final.

Romanian National Handball Team started the competition at the France EHF Euro 2018 with remarkable matches, recording 3 wins out of three group matches. The most outstanding win of all was that against Norway, the defending champion at that time. Romania's goal, that of reaching top 6, was attained, as the team ended the European Championship in the 4th position (out of 16), losing the match for the third position to the Netherlands. They have also secured their qualification to the 2019 World Championship from Japan, without having to go through play-offs.

In what personal achievement is concerned, Elena Buceschi (playmaker), ranked the 2nd on the scorers leaderboard, with 45 goals, and Cristina Neagu (back player), the 3rd (44 goals), becoming, at the same time, the player with the most goals ever scored (237), outperforming the Hungarian player Agnes Farkas (205). Crina Pintea was included in All Star Team and was awarded Best Pivot trophy, while the goalkeeper Yulya Dumanska received a nomination in the Player for the Future category. In the defense area, Cristina Neagu ranked the 2nd and Gabriela Perianu, the 4th among the "Best defender by average" category.

The physical shape, the outstanding results, strength and group cohesion proven in the first games announced an unprecedented performance of the Romanian team at the end of the championship. The key moment that greatly influenced the team's subsequent performance was the injury suffered by the most valuable player of the team in the game against Hungary. The injury occurred in minute 52 and Romania lost the match by a 2 goals margin. The player was diagnosed with torn anterior cruciate ligament in her right knee. Thus Romanian National Team lost, before the decisive moments of the competition (semifinal and final), their captain and main scorer at that time (44 goals). The absence of the team leader destabilized the tactical strategy and had a strong emotional impact on her playmates (Neagu, C., 2018). The qualification to the semifinals was a result of the favorable outcome of the Netherlands-Germany match, which ended with the general score 27-21. The semifinal with Russia was lost by Romania (28-22), and the Netherlands won the match for the 3rd position (the small final), Romania missing once again the chance for a bronze medal.

Methods

In order to collect the necessary data for the present study, we have recorded the cumulative indicators present on the European Handball Federation website and used video analysis to trace the collective performance throughout the eight games, laying special emphasis on the team's performance after the injury of a top player.

The cumulative indicators used to compare the games included indicators for the attack phase in each match: the efficiency of goals/attacks, the efficiency of goals/shots, the efficiency of fast breaks, the efficiency of the goalkeeper and the efficiency of position throws (wing, pivot, back court, fast break, and 7-meter). To interpret the data collected, we used common scientific methods of research, as statistical and mathematical calculation (the mean and percentage) and graphical representation (column and line chart).

Results

Table 1. Number of goals and the efficiency of attack phases

Matches Played	All		Position Attacks		Fast Breaks	
	Goals/Attacks	%	Goals/Attacks	%	Goals/Attacks	%
CZECH REPUBLIC	31/52	60%	31/50	62%	0/2	0%
GERMANY	29/51	57%	25/46	54%	4/5	80%
NORWAY	31/53	58%	29/49	59%	2/4	50%
NETHERLANDS	24/53	45%	21/48	44%	3/5	60%
SPAIN	27/58	47%	23/54	43%	4/4	100%
HUNGARY	29/50	58%	28/49	57%	1/1	100%
RUSSIA	22/52	42%	20/49	41%	2/3	67%
NETHERLANDS	20/60	33%	17/57	30%	3/3	100%
TOTAL	213/429	50%	194/400	49%	19/27	70%

Romania recorded, after 8 matches, a number of 429 attacks, finalized with 213 goals, an efficiency average of 50%. In table 1, one could see that, during the first three games at the group stage, Romania performed above average efficiency of the attack phases, which afterwards decreased during the games with the Netherlands and Spain, and then increased again by 8% above average. From this moment on, the team records a significant decrease of efficiency on the attack phases, down to a 33% efficiency, 17% below average, in the last game. Out of all attacks, 91% were finalized with a goal from position attacks, and the other 9%, in fast break phases. This can be explained by the fact that the attack phase was designed to make the team backcourt players stand out, especially the left back, a fundamental player capable of think over the game phases so as to highlight her or her playmates' qualities. After the match against Hungary, one can notice an obvious decrease of the efficiency rate on the positional attack phase, the team recording the lowest efficiency rate (30%) in the last game, the small final, against the Netherlands.

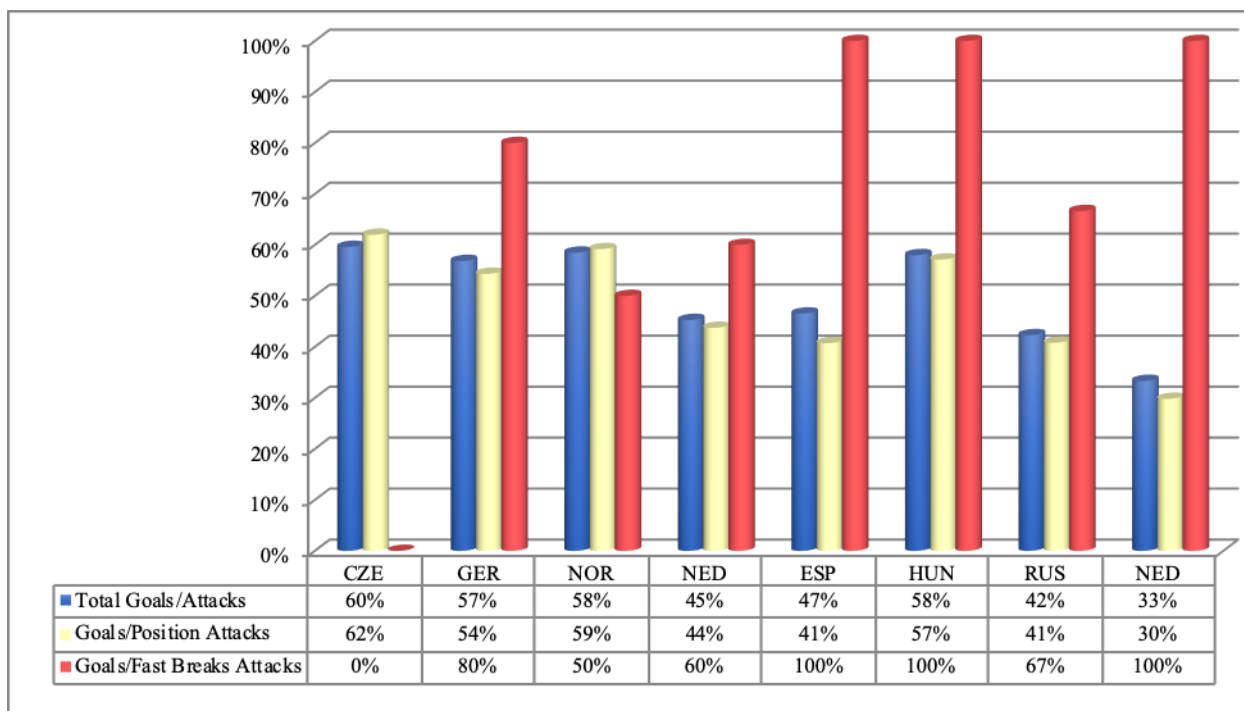


Figure 1. The evolution of goals by attack phases

Table 2. Number of goals and the efficiency of position shots

MP	Goals/Shots	%	6mC	%	Wing	%	9m	%	7mP	7m%	FB	%
CZE	31/45	69%	7/10	70%	9/12	75%	7/14	50%	5/6	83%		
GER	29/45	64%	7/10	70%	6/10	60%	4/10	40%	6/8	75%	4/5	80%
NOR	31/48	65%	5/6	83%	9/14	64%	8/17	47%	5/6	83%	2/3	67%
NED	24/50	48%	3/8	38%	5/8	63%	5/20	25%	4/4	100%	3/5	60%
ESP	27/43	63%	6/8	75%	3/6	50%	7/16	44%	2/2	100%	4/4	100%
HUN	29/49	59%	9/16	56%	3/6	50%	12/18	67%	3/7	43%	1/1	100%
RUS	22/47	47%	5/6	83%	3/7	43%	9/28	32%	2/3	67%	2/2	100%
NED	20/48	42%	1/3	33%	6/12	50%	7/25	28%	0/1	0%	3/3	100%
TOTAL	213/375	57%	43/67	64%	44/75	59%	59/148	40%	27/37	73%	19/23	83%

Legend: %- Efficiency; 6mC- 6 meters Center Shots; wing- Wing Shots; 9m- 9 meters Shots; 7mP- 7 meters Penalty Shots; FB- Fast Break

Table 2 comprises information on the total number of shoots and goals, as well as on the position from where they were scored. Romania team had 375 shooting positions, out of which they scored 213 goals. At the end of the competition, Romania ranked 4th in top scorers list, after Norway, France and Russia. The evolution of the goal rate is uneven, above the 57% average in the first three matches, with a decrease in the game against the Netherlands in the Main Group, followed by the rising to 63% and 59% during the matches against Spain and, respectively, Hungary. One could again notice the dramatic decrease of the efficiency in the last two games, with the lowest values of the shooting efficiency (47% and 43%). The most goals were scored from 9 m shots, and the best percentage of position shots was recorded at 6 m Center shots. The good performance on the pivot position is owing to the undeniable value of the player in this position, but also to the numerous assists from the 9 m players, especially from the left back. The latter's absence determined the decrease of collective efficiency and, implicitly, the decrease of

the personal efficiency of the players, especially at the level of center and 9 m shots, where the efficiency decreased, in the last match, almost by a half of the average (6mC % – 33%, as compared to 64%, 9m %– 28%, as compared to 40%).

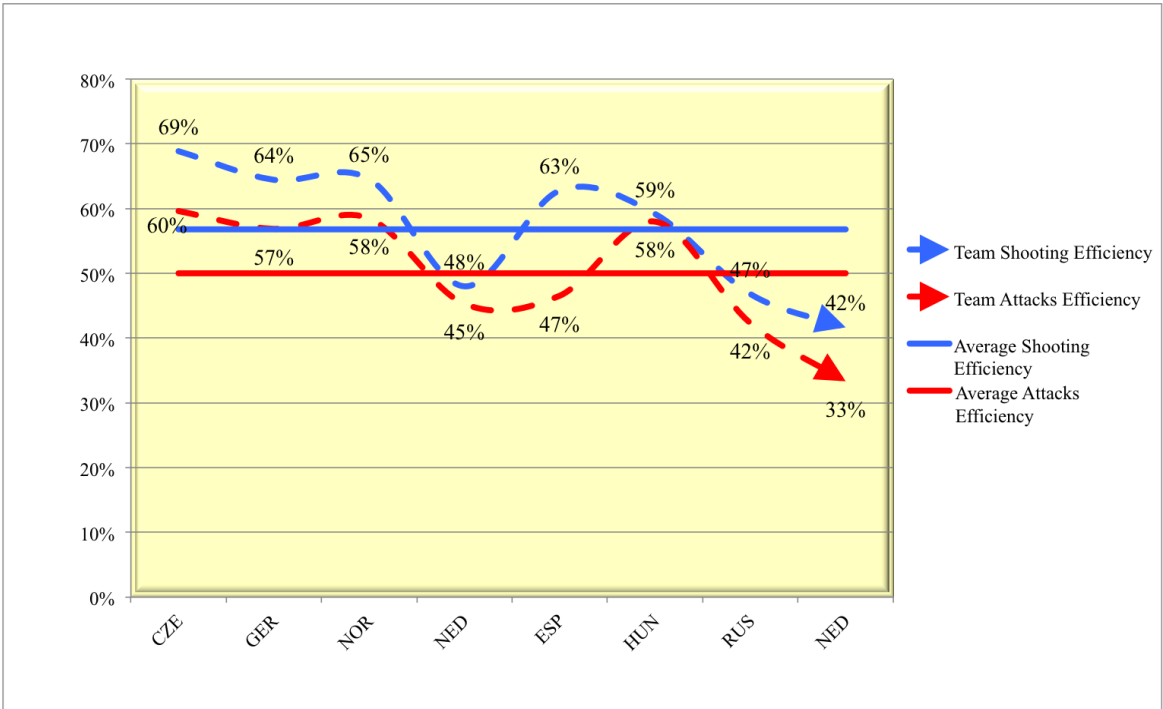


Figure 2. The overall evolution of team shots and attacks efficiency

Table 3. The overall evolution of Goalkeepers efficiency

MP	TOTAL		All saves/ shots									
	Saves/Shots	%	6mC	%	Wing	%	9m	9m%	FB	%	7mP	7m%
CZE	14/42	33%	0/2	0%	4/11	36%	8/18	44%	1/5	20%	1/4	25%
GER	13/37	35%	0/6	0%	5/12	42%	5/9	56%	1/4	25%	2/4	50%
NOR	15/38	39%	1/6	17%	6/13	46%	6/8	75%	0/4	0%	1/5	20%
NED	13/42	31%	3/8	38%	0/6	0%	7/17	41%	1/3	33%	1/4	25%
ESP	11/36	31%	2/5	40%	2/5	40%	3/8	38%	3/10	30%	1/2	50%
HUN	5/36	14%	1/4	25%	0/7	0%	1/5	20%	0/5	0%	1/4	25%
RUS	9/37	24%	1/4	25%	0/5	0%	6/14	43%	1/3	33%	1/7	14%
NED	13/37	35%	2/5	40%	1/3	33%	7/19	37%	1/3	33%	2/3	67%
TOTAL	93/305	30%	10/40	25%	18/62	29%	43/98	44%	8/37	22%	10/33	30%

In what the efficiency of the goalkeepers is concerned, one could see a different situation from that of the court players. The goalkeepers’ performance was above average during the first four matches, however, unlike the court players, who recorded the lowest efficiency during the attack phases during the last match, with the Netherlands, the goalkeepers’ lowest efficiency rate was recorded in the match against Hungary (14%, as compared to a 30% average). Their ulterior performance, in the semifinal and final, recorded increased rates of 24% and respectively 35%. The injury of the titular left back did not have the same effect over the goalkeepers’ performance as over the court players, as obvious from the data recorded in Table 3 and the graph below. This

can be accounted for by the fact that the injury of a court player does not affect her game relation with the goalkeeper, but rather that with her playmates in the surrounding positions in the court.

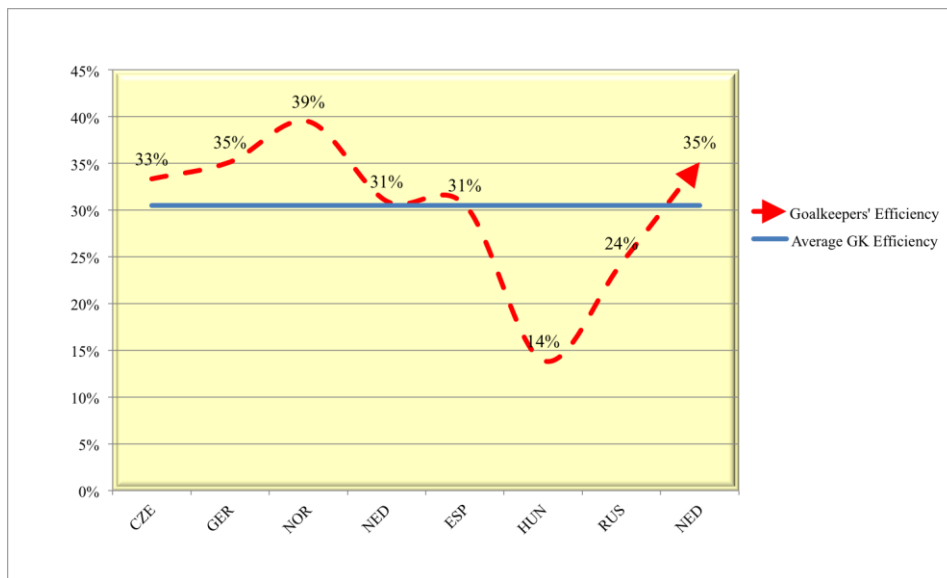


Figure 3. The overall evolution of Goalkeepers efficiency

Conclusions

The comparative analysis of the Romanian team's performance with and without the support of a top player provides a clearer image of the impact of injuries over the subsequent, immediate performance of the team. The game strategy of the Romanian team was oriented towards the maximization of the huge potential of the titular left back. Personal accomplishment did not fail to appear – as a result, at the end of the championship, she ranked the 3rd in top scorers, with 44 goals in just 6 matches (6 goals less than the 1st ranking player) and the 2nd in best defense players, she smashed the world scoring record and, eventually, she was awarded the title of Best World Player for the fourth time in her career.

According to the statistical data recorded, the absence of a fundamental court player affected the team play structure, especially in the attack phases, without having any negative effects on goalkeepers. Although it is a well-known fact that the goalkeepers' contribution is around 50% of the team play, their good performance did not suffice. This data comes to complement the press statements of the players and technical staff, who claimed that the Romanian players experienced a mental block and that they would have needed more time to regroup in order to tackle the remaining games without the injured player's support. The Romanian players' emotional imbalance and weakened shape were the main factors that prevented the team from winning a medal in this championship.

It is well-known that injuries cannot be prevented, therefore, we consider it necessary that coaches decide alternative technical and tactical strategies that can substitute the absence of one or more fundamental players at any moment during the game, especially in the case of major competitions. Greater emphasis should also be laid on psychological training, so that the players be able to effectively deal with critical moments.

Eight years after the last notable performance, the Romanian team qualified for the semi-finals of the European Handball Championship in France from the second position in the second group, playing in the semi-finals against the Olympic champion, Russia. Defeated in this game (28-22), they played in the small final against the Netherlands, but they lost this game too (20-24), ending the competition on the 4th place. With spectacular but also not so good matches, the Romanian team showed a quality handball, being one of the pleasant surprises in this competition. Their game playing is not accurately reflected in their ranking at the end of the European Championship because, had the leader and captain played in the last two matches, a long-awaited and well-deserved medal could have probably been obtained.

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DIFFERENCES IN ATTENTION ATTRIBUTES FOR FEMALE HANDBALL PLAYERS

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Summary

The article shows the differences in the attention properties of handball players of different game positions. Two of the important properties of attention such as volume and concentration (intensity) were studied both for each individual handball player and groups of players of different positions. The data obtained allow us to determine the directions for further improving of handball players and help to form the most suitable bundles of players for the quality of game interaction.

Keywords: attention volume, attention stability, concentration, information processing speed, handball players of different game positions.

Introduction

Increased competition among women's handball teams at major international competitions and the domestic Championship of Russia among super league teams dictates the need to further improve the training system for highly qualified handball players. One of the important areas for improving the system of sports training in handball is the study of various individual psychological indicators of handball players and the possibilities of their improvement in order to increase the effectiveness of competitive activity indicators. In this regard, the study of the characteristics of the attention properties of handball players of different game positions becomes relevant, as it creates the possibility of a directed increase in their individual manifestations, which, in turn, can affect the quality and stability of the performance of technical and tactical actions in competitions - especially in the conditions of growing fatigue.

The purpose of the study is to identify indicators of the properties of attention of highly qualified handball players of different game positions.

Methods

The study involved 26 handball players aged 18-19 years. To assess the properties of attention, a 4-minute test was used - a proof test according to the Bourdon method. Handball players had to look at the signs sequentially for 4 minutes. The volume of scanned characters for each minute, the intensity of work (which also characterizes the speed of information processing), and the stability of attention were evaluated.

Results

To the structural characteristics of attention, i.e. the signs that persist for all types and properties of attention include the following: stability, distribution, volume, concentration, switching.

Two of the most important properties of attention for handball players are the volume and concentration of attention.

The amount of attention characterizes the number of objects that can be captured in the shortest period of time. Usually this number is 4-6 objects. However, isolated cases of instant counting of about two hundred objects are known. When organizing attacking actions, handball players must include up to 12 objects - 5 partners, 6 field players and goalkeeper of the opposing team and the ball. In defense, the handball player also needs to control the movements of all players of the opponent team, the movement of teammates and the movement of the ball.

Concentration of attention is the absorption of attention by one object. Sometimes the concentration of attention is also called the intensity of attention. By itself, concentration of attention does not mean a high quality of task performance. Sufficient volume and distribution of attention is still needed.

Thus, in our study, investigated the features of two of the most important attention properties of highly qualified handball players of different roles.

Research results

A preliminary analysis of the effectiveness of the game activity of the team of handball players demonstrates the presence of certain dynamics of erroneous actions in the competition games - ball loss during dribbling, passing and catching, other inaccuracies.

The study of the volume of attention of handball players of different game positions in the test with proof-reading breakdown showed that the best indicators, as expected, have center back players - 1435 signs and left wings players (1205 signs). The smallest value of the attention volume was also revealed for handball players of the right wings function - 1171 signs (Table 1).

An analysis of the concentration of attention of handball players showed that the best indicators have back players (268,8), the worst – goalkeepers (88,4).

Taking into account the mistakes made by the handball players, the index of accuracy of attention was calculated. In this indicator, the best results are the back players (0.92) and the left wings (0.88). Linear players showed the lowest results (0.79).

According to the net workability indicator, the priority belongs to the point guard players, which fully proves that this role belongs to.

Table 1 - Average attention properties of handball players of different game positions

Game positions	Volume of attention	Concentration of attention	Attention accuracy index	Clear performance	Pace, sg./min
Goalkeepers	1191,75	88,4	0,84	992,88	297,94
Pivots (linear)	1188,67	131,7	0,79	919,72	297,17
Center back	1435,67	99,8	0,83	1190,73	358,917
Left wings	1205,5	179,9	0,88	1058,32	301,38
Right wings	1171	99,9	0,81	955,31	292,75
Back players	1171,6	268,8	0,92	1075,524	292,9
Min	1171	88,4	0,79	919,72	292,75
Max	1435,67	268,8	0,92	1190,73	358,917

Analyzing the pace of the task, namely, the average number of viewed characters per minute, it was revealed that this indicator also has the best central back players in the team and the left wings ones (358.9 and 301.4 characters, respectively).

Given the importance of attention sustainability in conditions of intense high-intensity gaming activity, it was important to identify the dynamics of the volume of processed information at certain intervals.

A 4-minute test with a proof breakdown showed various options for the dynamics of this indicator. So, the goalkeepers demonstrate a gradual increase in volume to the end of the work, which characterizes a slower integration into the intensive work of attention (Table 2). Linear players demonstrate a second starting position at the beginning of the work, a decrease in the 2-nd minute and an increase in volume by the end of the test.

The best indicators of a steady volume of attention were identified in center back players, who systematically increased their indicators by the end of work (with an insignificant decrease in the 2nd minute). At the same time, they have the best performance indicators.

The left wings players demonstrate a completely different picture - starting from not the highest indicators, at the 2nd minute they slightly increase the amount of processed information, and then reduce the volume at each minute until the test is completed, showing the negative dynamics of attention volume stability.

The right wings players begin to work with almost the same volume of characters viewed with the left wings, and then demonstrate a strong jump in the 2nd minute, a sharp decrease in the 3rd minute and a slight surge in the last.

Table 2 - Dynamics of the amount of processed information by handball players of different game positions

Game positions	<i>Volume of attention, amount of signs</i>			
	1-st min.	2-nd min	3-rd min	4-th min
Goalkeepers	274,5	296,0	294,75	326,5
Pivots (linear)	306,3	272,7	290	319,67
Center back	336,6	341,2	363,33	394,67
Left wings	292,5	310,8	306,75	295,5
Right wings	290,3	330,3	270,67	279,67
Back players	305,2	290,4	296,2	279,8
<i>Min</i>	274,5	272,7	270,67	279,67
<i>Max</i>	336,6	341,2	363,33	394,67

A study of the dynamics (stability) of the attention volume of liner players showed that with a generally not the highest amount of information being processed, they showed relative stability of the attention volume with a tendency to some decrease towards the end of the work.

Another indicator no less interesting for analysis is the speed of information processing and the preservation of speed during the test (Figure 1).

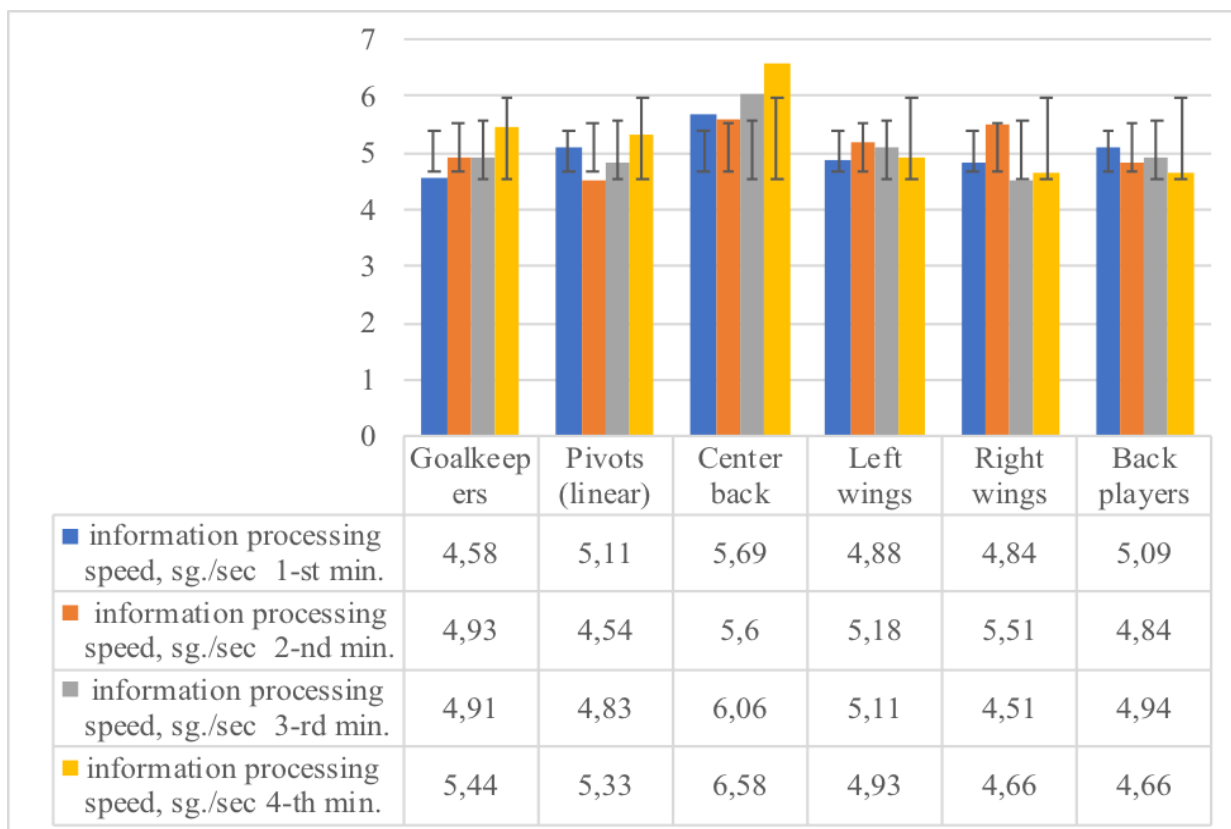


Figure 1 - The speed of information processing by handball players in the test

The highest speed of information processing (attention intensities), as one would expect, was shown by point guards - 6.58 characters per second. Moreover, it is most important that this speed was shown at the 4th, last minute of the test, which characterizes the high productivity of the attention of this sample of players. Starting speed was also the highest among central players (5.69 characters / sec). Goalkeepers showed the lowest starting speed - 4.58 characters per second.

Goalkeepers also showed a steady increase in the processing speed of information, players of the remaining roles showed not only an abrupt picture of the dynamics of speed, but also its decrease among welterweight players.

Discussion

The data obtained are of great practical importance in the formation of game “twos” and “triples” of sportswoman’s interaction, since it will be quite difficult for players with diametrically different indicators of attention properties (especially information processing speed) to ensure the quality of technical and tactical interaction in a rapidly changing game situation, which, in turn, can lead to an increase in technical and tactical errors and ball losses.

The use of special exercises in training sessions can increase many indicators of attention. As numerous observations show, special work to increase the stability of attention indicators allows to some extent reduce the number of erroneous actions of athletes. Knowledge of the individual characteristics of handball players allows you to select the gaming links closest to these indicators. On the whole, on command, this allows to reduce the number of ball losses in conditions of high psycho-emotional tension of the match and increasing physical fatigue.

Conclusions

Our research results allow us to conclude that the identification of the characteristics of the attention properties of the players of the handball team is of great practical importance. An increase in individual indicators of the volume and concentration of attention, the speed of processing information, as the intensity of attention, allows the coach to optimize the training process and helps improve the quality of the game for all handball players of the team.

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FEATURES INJURIES HANDBALL PLAYERS 18-20 YEARS OLD IN COMPETITION

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Summary

The most talented young handball players start to move from youth to the teams of men clubs and then replenish the ranks of the national team, while others, having been injured, say “goodbye” to handball. The study analyzes a comparison of injuries of handball players of 18-20 years old, identify the main types of injuries of handball players of different ages and game positions in order to develop and apply effective means of injury prevention at the earlier stages of long-term training.

Keywords: localization of injuries, the nature of injuries, the time of injury, injuries of players of different positions.

Introduction

Professional sports are inevitably associated with the risk of injury. Handball, in turn, refers to sports with a high level of injury. The issues of injuries in sports and methods of its prevention at different times were studied by many specialists.

Handball is a contact sports game. Injuries of the musculoskeletal system in handball account for 80% of the entire pathology. E.A. Kuzmina and O.S. Bulychev determined the structure of injuries in handball [3].

As can be seen in Figure 1, the most characteristic for handball players are:

- injuries of the knee joint (ligamentous apparatus, menisci) that occur when jumping and abrupt change of direction (turns) - 24%;
- injuries of the shoulder joint arising from contact with an opponent while shooting the ball on goal - 16%;
- injuries to the wrist and fingers that occur when in contact with the ball - 23%.

These injuries occur, as a rule, when falling onto a palm with an outstretched arm, the scaphoid bone is most often affected, less often the lunar bone. Fractures of the phalanges of the fingers of the hand are mainly the result of a direct impact of force, and, as a rule, a blow falls on the back surface of the fingers or along a long axis.

Issues of reducing injuries, eliminating risk factors for their receipt in handball are the most important task in organizing training and competitive activities of both young and highly qualified athletes. This is the relevance of this study.

Methodology.

Even before the European Championship 2018 for handball players no more 18 and no more 20 years old, the participating nations were informed of the planned implementation of the injury study, in writing.

Those forms that were of use during European Championships were employed for the recording of injuries and their respective problems.

The team doctors, as well as the medical supervisors, were asked to register all injuries irrespective of whether they occurred during a game (or during a training session). For purposes of unity, a standardized code was utilized describing the type and location of the injury, the expected absence period from games (or training sessions).

The reports were collected from every team and every game, regardless of whether an injury occurred or not. The collected data were strictly confidential and accessible only to those persons, who were involved in the study.

The both tournament of the European Championship among handball players 18 and 20 years old included 3 stages - preliminary, intermediate and main. Over 11 days, teams (a total of 256 participants) played 56 matches.

Results and discussion

An analysis of the official reports of the team representatives at the European Championships 2018 for players no older than 18 and no older than 20 years revealed some trends (Figure 1). An analysis of the most injured parts of the body of handball players aged 18-20 shows that the overall picture is similar in both age groups. At the same time, handball players under 18 years of age more often injure the lower limbs.

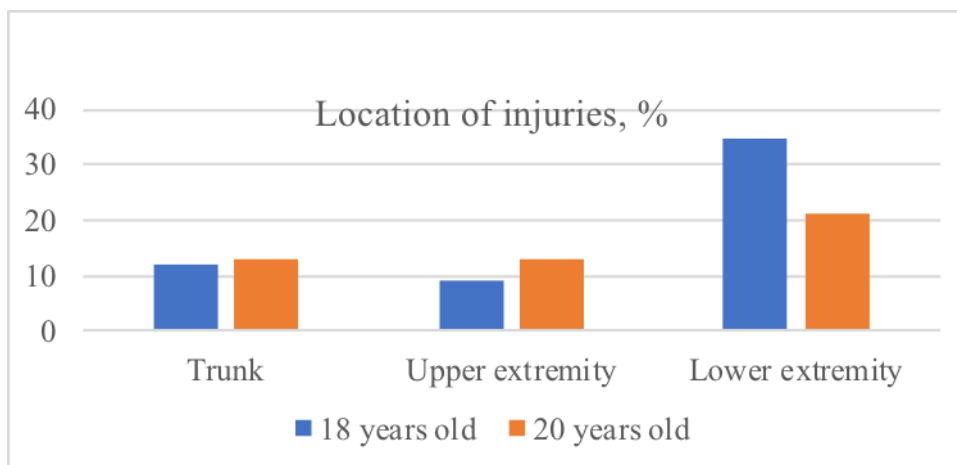


Fig. 1 – Location of injuries of handball players 18-20 years old

The main types of injuries to handball players under 18 years old (16-18 years old) are contusions of various parts of the body sprains (Fig.2). Handball players for 20 years old receive similar injuries (Tab.1). The main injuries to handball players are in force contact with an opponent, during touchdowns after throwing and passing the ball in a jump and in sudden stops and changes of direction

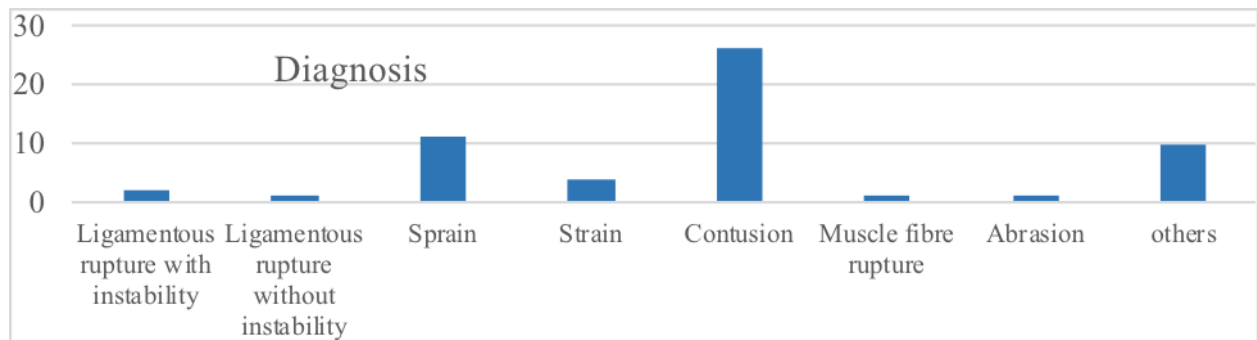


Fig.2 – Diagnosis of injuries of handball players 18 (and less) years old

Table 1 - Diagnosis of injuries of handball players 20 (and less) years old

concu sion with loss of	fracture	dislocation	muscle fibre rupture	tendon rupture	ligamentous rupture with instability	ligamentous rupture without instability	sprain	strain	contusion	others
2	2	2	2	1	1	2	8	5	18	1

It should be noted that in a quantitative sense a greater number of these injuries belong to the handball players under the age of 18 years. The differences are 11 cases. An analysis of the injuries of 18-20 years old players of different positions in a competition also shows significant differences (Figure 3). The most injuries are players in the backcourt – center backcourt and line players (for 20 years old).

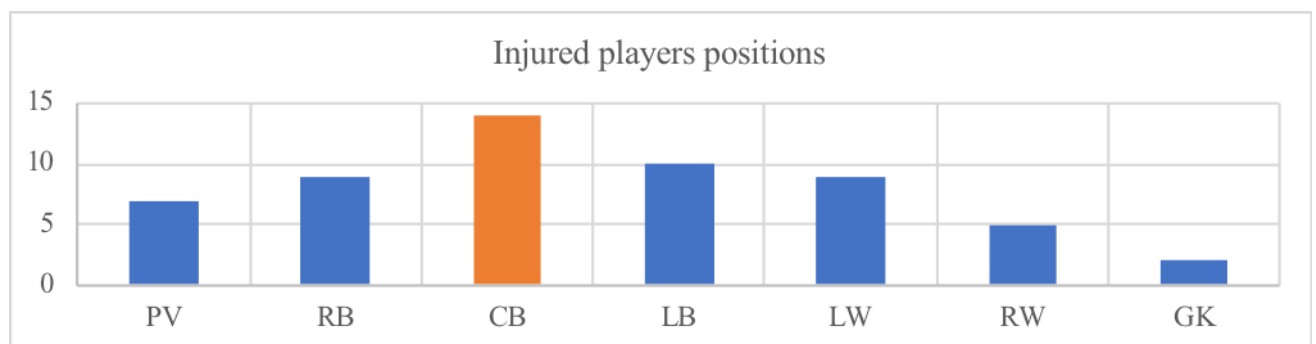


Fig.3 – Game positions of injured players

As can be seen from Figure 4, handball players under 18 receive the greatest number of injuries in the last 10 minutes of the 1st half of match and in the middle of the second half. In this case, injuries in the second half have higher rates in relation to the first half, which may indirectly indicate player fatigue.

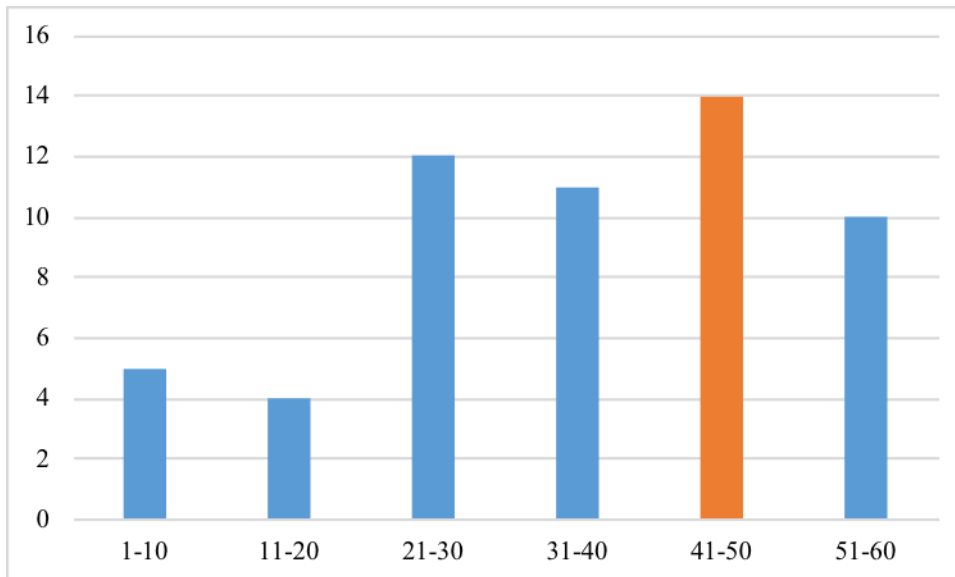


Fig. 4 - The time of injury in the game by handball players 18 years

The analysis of the time of injury during the game of handball players under 20 has a completely different picture (Figure 5) - the number of injuries is steadily increasing by the middle of the 2nd half.

A comparative analysis of these data for players 18 and 20 years old may indicate a higher level of functionality and better technical and physical readiness of handball players 20 years.

Comparison of these indicators for handball players of 18 and 20 years old shows that for more younger athletes 1st period of the match is especially traumatic - 21 injuries occurred in the first half of the matches. More experienced and trained handball players for 20 years in the first half of the match for the entire tournament received only 12 injuries.

Injury of handball players in the second half of the match for handball players of 18 and 20 years of age does not practically differ in quantitative terms (35 and 33 injuries, respectively).

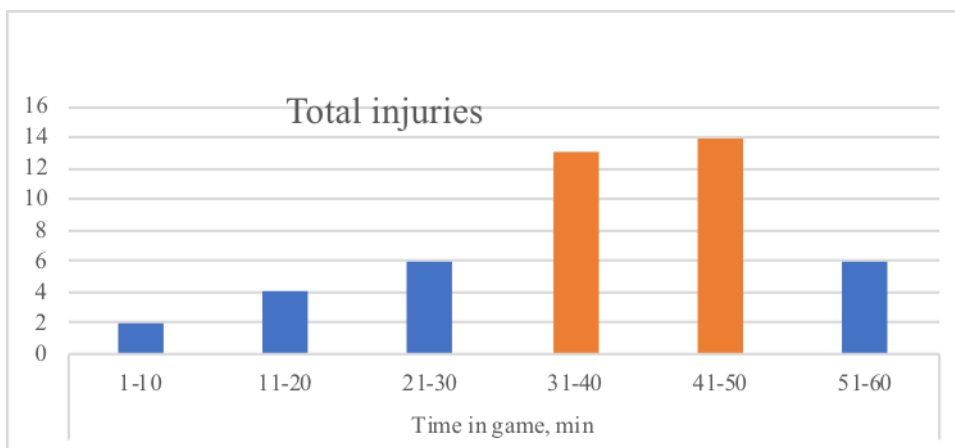


Figure 5 - The time of injury in the game by handball players 20 years old

An analysis of the conditions for injuring handball players shows that most injuries to athletes occur in contact with an opponent (Fig.6). At the same time, attention should be paid to the fact that handball players of 18 years of age are injured more often than 20 year old players by contact with an opponent. This can be explained by the insufficient level of technical and physical fitness of athletes of this age category.

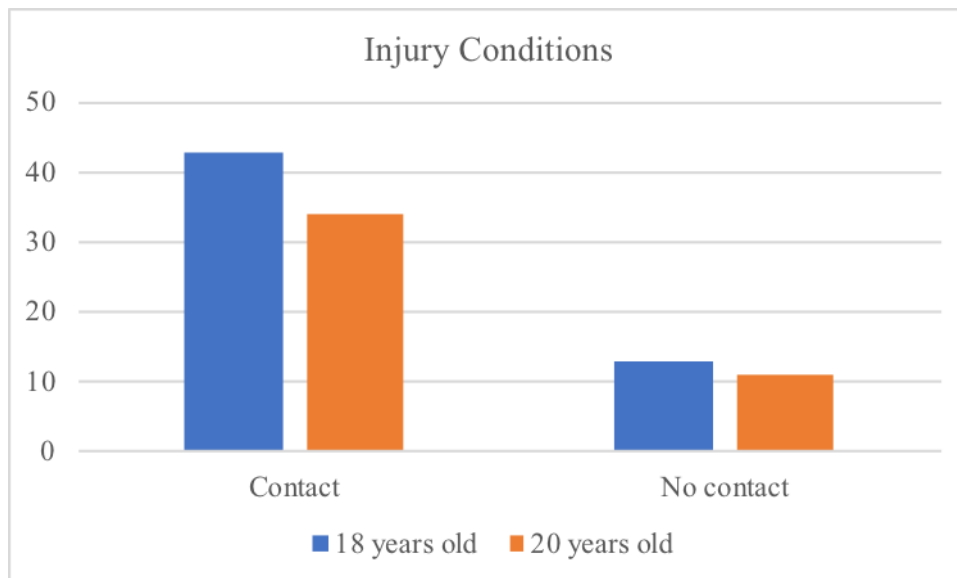


Fig. 6 – Conditions for injuring handball players

The tournaments of the European Championship among handball players 18-20 years old included 3 stages - preliminary, intermediate and main rounds. Over 11 days, teams (a total of 256 participants) played 56 matches.

The total number of recorded injuries was 56 (18 years old players) and 45 (20 years old) for during official matches, 1 injury was received during training and 1 injury during warm-up of the team before the game.

A long tournament with increasing tension of matches in the struggle to achieve the highest possible result by teams is characterized by different dynamics of getting handball players. Handball players 18 years old are almost 2 times more likely to receive injuries in the final part of the tournament (Fig.7). This indicator may indirectly indicate an increase in uncompensated fatigue in younger handball players associated with insufficient functional readiness and physical fitness of athletes of this age group.

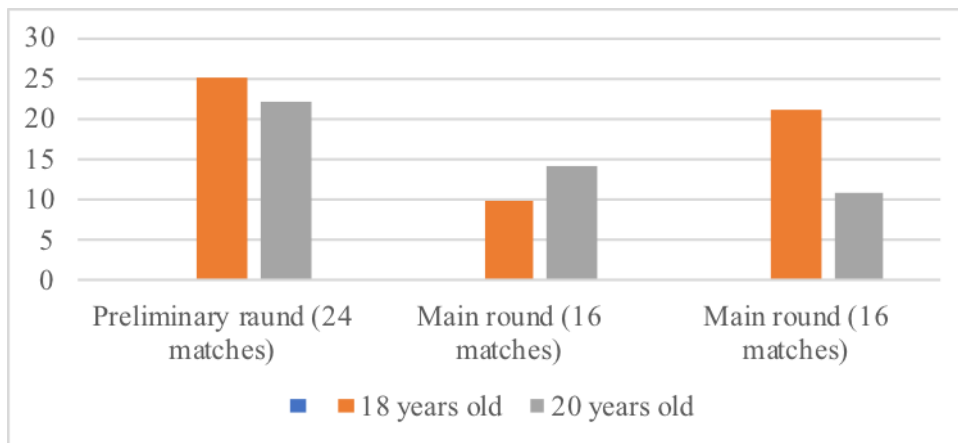


Fig.7 - Differences in injuries of handball players of different ages on European Championships among handball players 18-20 years old

Conclusions

Thus, the data obtained allow us to draw certain conclusions.

1. The main injuries to handball players are in force contact with an opponent, during touchdowns after throwing and passing the ball in a jump and in sudden stops and changes of direction.
2. A large number of injuries prove the need for more thorough physical and technical training of handball players before the age of 17-18, the development of special exercise programs aimed at strengthening the musculoskeletal and ligamentous apparatus of athletes.
3. It is necessary in the training process to pay closer attention to the technique of performing techniques and motor actions by athletes, to improve the coordination abilities of athletes.

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COACHES' EMOTIONAL SKILLS AND INTERPERSONAL BEHAVIOURS IN SPORTS COACHING

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Summary

For a long period, the research towards sport coaches focused on behavioral or cognitive variables, separately. Nevertheless, some studies highlighted the importance and the relevance of studying behavioral and cognitive processes together due to the fact that they complement each other. We simply believe our study adds comprehensive evidence to suggest that coach education programs need to include emotional skills training and provide some productive starting points for investigating the role of emotions in sports training.

Keywords: coaching, coach education, emotional intelligence, psychological needs, interpersonal behaviours

Introduction

In the different sports, there is a multitude of roles fulfilled by players, sport coaches and referees (Catteuw, Helsen, Gilis, & Wagemans, 2009). It seems hard to believe that whenever the aim at improving sport performance existed, coaches, their behaviour and training have been considered as variants with short impact upon this aim, stated Lyle in the early 21st century (2002). Nowadays it is currently unavoidable consider that athlete's performance, his relationship towards sportive success is the visible face of what goes on during training sessions and competition.

The study of sport performance as a consequence of the training process allows the fulfilment of the competition aims, i.e., the sport success (Rodrigues, 2017), so it is expected that the coach, during the training period, provide his athletes with all means so that they can succeed in competition.

The performance of the sport coaches' functions is ruled by a set of formal aspects depending on the characteristics of the game and regulation of the competition (Arroyo & Alvarez, 2004). In order to optimize the training process in a way that allows its full application in competition, the sports coaches will have to spend important time upon the planning tasks (pre-interactive decisions) and evaluation ones (post-interactive actions). During the training sessions, coaches' behaviours will be conditioned by the pre-interactive decisions, but always subject to the unexpectedness of the training sessions (Lyle, 2002). After each training session, sport coaches' main concern will focus upon the post-interactive decisions, which will then influence the pre-interactive decisions of the following training session or competition and so on. It is always a cycling process between decisions and behaviours. Therefore, it seems that there are different factors towards sport success, upon which the sport coach's role and responsibilities should be highlighted and not underestimated.

For a long period, the research towards sport coaches focused on behavioural or cognitive variables, separately. Nevertheless, some studies (Hanke, 1991; Côté *et al.*, 1995; Gilbert, Trudel & Haughian, 1999; Cloes, Bavier & Piéron, 2001; Sequeira, Hanke & Rodrigues, 2017)

highlighted the importance and the relevance of studying behavioural and cognitive processes together due to the fact that they complement each other.

Sequeira, Hanke & Rodrigues (2017) focus their study upon pre-interactive decisions, behaviours and post-interactive decisions of 6 top handball coaches, during the most important Handball Championship in Portugal. Three games per coach were videotaped, during three weeks. Before and after each game one interview took place. Each coach was interviewed 6 times (3 times before the game and 3 after the game). The sample was composed by 18 games and 36 interviews. Two data collecting tools were used in the study: SOTA (Observation System of the Behaviour of Coach) and interview. They concluded that the behaviour of handball coaches in competition is planned and always reflected, but it shows some incoherence in the relation between pre-interactive decisions, behaviours and post-interactive decisions. They also understand that the behaviour of the handball coach during the game is very unstable and improvable making difficult the search for a behavioural pattern at this level of competition.

Many other studies made similar approaches. From this set of studies, we underline the importance to approach the sports coach through all his variables. When a sports coach is in action, everything is important. If we look only from some parts, there is a huge possibility to make wrong analyses and discussions. Studying sports coaches in the next years should take this in consideration.

Beyond the important circular process between coaches' decisions and behaviours (Sequeira, Hanke & Rodrigues, 2017), i.e., the complementarity between cognitive processes and behaviours, we must keep in mind that the coaching process in sport is framed in an empowering, mutual trusting and respectful coach-athlete relationship recognized as a powerful performance factor. The key strength of this positive approach is the major role played by the sports coach in promoting motivational coaching environments (Cotê, 2009; Ntoumanis & Mallet, 2014) and shaping the psychological experiences his athletes derive from their sport participation (Mageau & Vallerand, 2003).

The study of emotion as a central aspect of social relationships is a largely neglected feature of the sport coaching literature where the cognitive perspective dominated (Potrac, Smith, & Nelson, 2017). Sport coaches' emotional competencies are a set of skills and understandings that are necessary to understanding an athlete's experience. On the other hand, in a positive youth development approach (Cotê, 2009), emotional skills allow young athletes recognize, express, and regulate their emotions, as well as engage in empathy and positive sustained relationships with adults, namely their sports coach (Humm, 2010; Kahn, Bailey & Jones, 2018).

This shifted focus to the role of emotions in sport coaching places emphasis on psychological factors that determine successful or unsuccessful experiences in sport. In this perspective, sports coaches' social and emotional skills and their interpersonal behaviours, particularly during the training process, acquire a renewed research interest.

According to Self-Determination motivation Theory (SDT: Deci & Ryan, 1985) it is possible to state that sport coaches' interpersonal behaviours determine athletes' experiences in sport through the extent to which these behaviours either support or thwart their athletes' psychological needs: autonomy, competence, and relatedness (Rocchi, Pelletier & Desmarais, 2016; Rocchi *et al.*, 2017). Those sport coaches' interpersonal behaviours may therefore constitute the promotion or prejudice to the quality of athletes' motivation.

The purpose of this study is to measure self-rated coaches' emotional skills and also their perception about own interpersonal behaviours with their athletes that support or thwart athletes' psychological needs and explore the relationships between both emotional and behavioural variables.

Methods

Participants

The participants in this study are handball coaches (N=51) ($N_{male} = 44$, 86.3%; $N_{female} = 7$, 13.7%) from a variety of backgrounds, for example, different qualifications, different experiences and different coaching contexts. Their ages range from 18 to 65 years with an average of 43.43 years (SD=11.08). They have qualifications spread across the four professional levels of coaching qualification and an average of 16.51 years (SD=3.45) handball training experience, coaching male teams ($N_{mg}=28$; 54.9%), female teams ($N_{fg}=18$; 35.3%) and both genders simultaneously ($N_{bg}=5$; 9.8%). Thirty six (70.69%) handball coaches completed university courses or are attending higher education.

Materials

The 33-item *Emotional Intelligence Scale* (EIS: Schutte *et al.*, 1998) is a six-factor model that assesses Emotional Intelligence in self and others, in terms of awareness, regulation, and utilization of emotions. This scale was initially developed for the general population and its validation offered a unifactorial solution, with an internal consistency (Cronbach's *alpha*) of 0.87 and a reliability-stability of 0.78. It was later adapted for use in sport (EIS-S: Lane *et al.*, 2009; García-Coll *et al.*, 2013) measuring six dimensions of self-rated emotional skills: self-emotional knowledge or the appraisal of own emotions (5 items: "I am aware of my emotions as I experience them"), social awareness and empathy by the appraisal of others emotions (7 items: "By looking at their facial expressions, I recognize the emotions my colleagues or athletes are experiencing"), emotional regulation by managing self-relevant emotions (5 items: "I have control over my emotions in training or competition"), social skills by managing others' emotions (5 items: "I like to share my emotions with others"), utilization of emotions (7 items: "When I experience a positive emotion, I know how to make it last") and optimism (4 items: "Emotions are one of the things that make my life worth living"). As a self-report test, participants were asked to reflect across their subjective perceptions evaluating each item on a 5-point Likert scale, with 1 totally disagreeing and 5 totally agreeing.

The *Interpersonal Behaviours Questionnaire* (IBQ) in Sport (Rocchi, Pelletier & Desmarais, 2016) assesses self-perceptions of interpersonal behaviours measured by 24 items in six subscales looking at autonomy-supportive ("Give them the freedom to make their own choices"), autonomy-thwarting (or controlling) ("Pressure them to do things my way"), competence-supportive ("Encourage them to improve their skills"), competence-thwarting ("Point out that they will likely fail"), relatedness-supportive ("Am interested in what they do"), and relatedness-thwarting ("Do not comfort them when they are feeling low") interpersonal behaviours (4 items each). The "Self-Form" was used to evaluate coaches' interpersonal behaviour when they coach their athletes, by a Likert-type scale from 1 "Do not agree at all" to 7 "Completely agree".

Results

Pearson correlation analysis showing the relationship between subscales among both instruments and respective means and standard deviations values of the scores of the study participants are presented in Table 1.

Table1

Descriptive statistics and correlations between the EISS and the IBQ-self variables

Subscales	Autonomy		Competence		Relatedness		Descriptive statistics	
	Support (AS)	Thwarting (AT)	Support (CS)	Thwarting (CT)	Support (AS)	Thwarting (AT)	Mean	SD
Self-emotional knowledge (SEK)	0.02	0.20	0.46**	0.03	0.22	- 0.12	3.90	0.46
Social awareness and empathy (SAE)	0.31*	- 0.01	0.41**	0.37*	0.45**	- 0.17	3.49	0.48
Emotional regulation (ER)	0.34*	0.20	0.48**	0.02	0.32*	- 0.27	4.07	0.41
Social skills (SS)	0.36*	0.11	0.39**	- 0.08	0.37	- 0.21	4.14	0.41
Utilization of emotions (UE)	0.45**	0.12	0.39**	0.03	0.32*	- 0.17	3.61	0.56
Optimism (Opt)	0.36**	0.07	0.19	- 0.17	0.19	- 0.06	4.33	0.43
Mean	5.38	3.74	6.31	2.80	5.93	1.72	---	---
Standard deviation (SD)	0.85	1.01	0.52	0.70	0.79	0.63	---	---

Note: N=51; * p<0.05; ** p<0.01.

Through the analysis of the descriptive values shown in table 1, it can be observed that the participating handball coaches perceive themselves as globally emotionally competent, emphasizing optimism as the most powerful emotional strength. The awareness and appraisal of others' emotions and the utilization of own emotions constitute the weakest points. On the other hand, they perceive their behaviour as particularly focused on promoting the competency of their athletes and strictly deny constituting a difficulty to a proper and caring interpersonal relationship with their athletes.

Several statistically significant relationships were found among subscales of both instruments, although the weak or moderate Pearson correlations coefficients. So, it is possible to link perception, regulation and utilization of emotions by coaches to their supportive (rather than thwarting!) behaviours in training or competition. We can still highlight the negative correlation ($r = -.37$) between coaches' perceived social awareness and empathy and his intentional competence-thwarting behaviour, alerting them to the possibility of failure or questioning them ability to overcome challenges.

We also found weak positive correlations between coaches' level of qualification and interpersonal behaviours for autonomy ($r = .30$; $p < .05$) and competence ($r = .30$; $p < .05$).

Discussion

In sport context, particularly in the training process, give support to athletes' basic psychological needs represents to improve motivation quality and other positive outcomes, such as improved

well-being (Milyavskaya & Koestner, 2011). Coaches can give chances to athletes to act on their own interests and values while practicing their sport (need for autonomy), or create opportunities for athletes to increase skill mastery (need for competence). Finally, coaches can further promote a relational environment with strong interpersonal connections with their athletes and other people involved in sport (need for relatedness).

In this study with handball coaches, results revealed a clear option for supportive behaviours (than controlling or thwarting) during the coaching process, which is considered, according to self-determination theory (SDT), a key point to promote the satisfaction of athletes' psychological needs and the increase of their motivation (Vallerand, 2001).

Conclusions

This study provides some productive starting points for investigating the role of emotions in sports training. Our understanding of sports coaching process as yet to examine how emotions play an essential role in helping coaches to narrow down “the range of potential actions into a manageable assortment” on which they can draw in their everyday practice (Potrac, Smith, & Nelson, 2017, 130).

Coaches with strong social and emotional skills seems to are more likely to have positive relationships with handball players enabling the use of effective leadership strategies through interpersonal behaviour that encourage them for autonomy, competence and the appropriate relatedness for developing intrinsic motivation.

Our study adds comprehensive evidence to suggest that higher qualified coaches (level 3 or 4) seem to promote more autonomy behaviours and the handball players' competences which leads us to suggest that coaching education programs need to include emotional skills training.

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Effects of training specificity into influencing agility and sprint performance of physical education students

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Abstract

The purpose of this study was to determine if straight sprint training transferred to agility performance tests that involved various change-of-direction complexities and if agility training transferred to straight sprinting speed in physical education students. Subjects were randomly divided into an experimental group (EG: n=10) and a control group (CG: n=10). Measurements of T-half test, 15 m and 30 m sprints were assessed in both groups before (T1), between (T2) four week and after (T3) a 10-week training intervention program, which included agility and speed training. We found time effects for the agility T-test ($p=0.012$, $\eta^2=0.245$) and sprint 15 m ($p=0.035$, $\eta^2=0.190$). A global interaction effect ($p=0.001$, $\eta^2=0.380$) was only found for the agility T-test. A partial interaction effect was also detected for the agility T-test from examination 2 to examination 3 ($p<0.001$, $\eta^2=0.603$). In this context, the EG showed a large effect size ($d=0.87$) from T2 to T3. The second relevant ($d\geq 0.5$) effect size was calculated for the parameter sprint 30 m. The CG showed a significant deterioration from T2 to T3 ($d=-0.60$) regarding the sprint performance over 30 m. All other effect sizes were less than 0.44. We concluded that straight speed and agility-training methods are specific and produce no limited transfer to the other. These findings have implications for the design of speed and agility training and testing protocols in physical education students.

Keywords: Change of direction, physical education; motor learning, agility training, sprinting

Introduction

Straight sprinting and agility are considered important qualities in many sports [1]. Sprinting in a straight line is a relatively closed skill involving predictable and planned movements and is used in track and field and teams sport [1]. Agility is difficult to define, but is often described as a quality possessing the ability to change direction and start and stop quickly [1, 2, 3]. In a sporting situation, agility and changes of direction may be initiated to either pursue or evade an opponent or react to a moving ball [4].

Therefore, it has been recognized that a component of agility performance is the response to a stimulus [1]. Several studies have reported correlations between straight sprint tests and various changes of direction and agility tests. When a correlation coefficient (r) is less than 0.71, the explained variance between the two variables is approximately 50%, indicating that they are specific or somewhat independent in nature [5].

A common variance of only 7% was reported for a straight 20-m sprint and a 20-m sprint involving three changes of direction of 90° in Australian footballers [6]. When the players were required to bounce a football twice while performing these changes of direction, the correlation with the straight sprint dropped to nearly zero. Corvo [7] suggested that sprint training has limited benefit for improving agility in rugby league players, and Gambetta [8] suggested that because of the need to change direction in American football, the importance of straight sprinting speed is diminished. Collectively, these findings and views indicate that straight sprinting and relatively complex agility maneuvers have little in common and are independent or specific qualities [1].

It would therefore follow that the training intervention of straight sprinting speed would have little transfer to agility and changes of direction performance and vice versa [4]. Since the potential specificity of speed and agility training has not yet been clearly established. The purpose of the present study was to determine if straight sprint training transferred to change-of-direction tests of varying complexities of physical education students. Another objective was to determine if agility training could enhance straight sprinting speed.

Methods

Subjects

All procedures were approved by the Institutional Review Committee for the ethical use of human subjects, according to current national and international laws and governing regulations. Participants gave their written informed consent after receiving both a verbal and a written explanation of the experimental design and its potential risks. Subjects were free to withdraw from the study without penalty at any time. A questionnaire covering medical history, age, height, body mass, training characteristics, injury history, and performance level was completed before participation. An initial examination by the team physician focused on orthopedic and other conditions that might preclude resistance training; however, all participants were found to be in good health. Participants were randomly divided between experimental and control groups. These groups were initially well matched in terms of physical characteristics (experimental group: age: 21.8 ± 0.5 years, body mass: 82.5 ± 5.8 kg, height: 1.80 ± 0.05 m, body fat $13.4 \pm 0.3\%$; control group: age: 22.1 ± 0.2 years, body mass: 83.2 ± 11.1 kg, height: 1.83 ± 0.03 m, body fat $13.8 \pm 0.1\%$).

Testing Schedule

Three similar sets of tests were integrated into the weekly training schedules. All measurements were made on a regular indoor court, under similar ambient conditions (temperature: 20.5 ± 0.5 C; relative humidity: $60 \pm 5\%$), at the same time of day (5:00 p.m. to 7:00 p.m.). To prevent effects of fatigue, intensive training was avoided for 24 h prior to testing. Participants also fasted for at least 3 hours. A standardized battery of warm-up exercises (5 min of low intensity running, 3 x 30-m progressive accelerations, and a maximal 30 m sprint, interspersed with 3-minute periods of passive recovery) preceded all maximal efforts.

The first set of tests, completed two weeks before the intervention, familiarized participants with the testing procedures, and allowed assessment of the 2-week test-retest reliability of

measurements. The second test was given between the intervention and third sets were completed immediately following the intervention.

15 m and 30 m Sprints

Sprint testing began with standardized dynamic warm-up (~10 min) followed by sub maximal 30-m shuttle runs at intensity of 60% to 70% of their maximum heart rate and 4 acceleration sprints, during the runs. Subjects ran 40 m from a standing position, with the front foot 0.2-m behind the starting photocell beam. Times at 15 and 30 m were recorded by paired photocells (Microgate, Bolzano, Italy) that were located 1 m above the ground at the starting and finishing lines. Three trials were separated by 6-8 min of recovery, with the fastest times being used in analyses.

Ability to Change Direction (T-half test)

A 15-minute warm-up included jogging, lateral displacements, dynamic stretching, and jumping. Standard T-half tests [9] were performed in random order, except that the total distance covered was reduced from 36.56 to 20 m. Data were recorded using an electronic timing system (Globus, Microgate SARL, Bolzano, Italy). Electronic timing sensors were set 0.75 m above the floor, 3 m apart and facing each other at the starting line [9]. Testing began with both feet placed behind the starting line A. Subjects sprinted forward to cone B and touched the base of it with their right hands. Facing forward and without crossing feet, they then shuffled to the left to cone C and touched its base with their left hands. They then shuffled to the right to cone D and touched its base with their right hands, subsequently shuffling back to the left to cone B and touching its base. Finally, they ran backwards as quickly as possible, returning to line A. Anyone who crossed one foot in front of the other, failed to touch the base of a cone, and/or failed to face forward throughout had to repeat the test. Three minutes of rest was allowed between trials [9]. Criteria for an acceptable test were as in the T-test, with recording of the better of two definitive trials.

Training program

The experimental group performed two training sessions per week of agility and sprints training, in addition to their usual physical education requirements, for 10 weeks. All training sessions began with a warm-up, consisting of 5 minutes of general exercises (low-intensity running, high skipping, leg flexions, lateral running, front and behind arm rotation, and sprints). The sessions were between 30 min and 45 min in duration including 1 to 2 minutes of recovery (Table 1). Each motor skill program consisted of 20 sessions during a ten-week period. In both groups, each session lasted approximately 30 minutes and consisted of three parts: (a) 3–5 minutes of introduction; (b) 22–25 minutes of skill instruction and practice; and (c) 2–3 minutes of lesson closure. The general feedback used in the study was purposefully administered so that there were no informational or controlling effects on the participants (e.g., “Well done,” “Good job”) [10].

Statistical Analyses

All statistical analyses were performed using SPSS version 25.0 for Windows (SPSS Inc., Chicago, IL, USA). Means and standard deviations of dependent variables were calculated across handball players. Differences between groups (EG vs. CG) and sessions (examination 1 vs. examination 2 vs. examination 3) were tested using a two-factor (time, group) univariate general linear model [11].

The effect size (d) (mean difference of scores divided by the pooled standard deviation) was calculated for each parameter [12, 13]. A positive effect size implies an improvement of performance and a negative value indicates a deterioration in performance.

Differences between means (group, time and group-time effects) were considered as statistically significant if: $p < 0.05$, and $\eta^2 > 0.20$ and $d \geq 0.5$ and $\Delta d \geq 1.0$.

Results

We found significant interaction effects (group x time) for the 10 week intervention in one of the three investigated performance parameters (Table 2). Only the Agility T-test ($p = 0.001$, $\eta^2 = 0.380$) displayed a significant inter-group difference.

A partial interaction effect was also only detected for the agility T-test between T2 and T3 ($p < 0.001$, $\eta^2 = 0.603$). In this context, the EG group showed a large effect size ($d = 0.87$) between T2 and T3. In contrast, the first period (T1 to T2) showed a small reduction of agility performance ($d = -0.07$; 6.37 ± 0.15 vs. 6.38 ± 0.15 s).

The second relevant ($d \geq 0.5$) effect size was found during the 30 m. The CG showed significantly slower 30 m sprint times between T2 and T3 ($d = -0.60$). All other effect sizes were less than 0.44.

Time effects were observed for the agility T-test ($p = 0.012$, $\eta^2 = 0.245$) and sprint 15 m ($p = 0.035$, $\eta^2 = 0.190$).

CG effect sizes ranged between -0.60 (sprint 30 m, T2 to T3) and 0.43 (sprint 15 m, T1 to T2). For agility T-test, we only observed negative effect sizes for both periods ($d_{1/2} = -0.18$; $d_{2/3} = -0.06$). In contrast, the effect sizes in the EG moved from -0.07 (Agility T-test, T1 to T2) to 0.87 (Agility T-test, T2 to T3).

Discussion

The evidence from this investigation showed that students in experimental group showed improvement in performance on locomotor during the intervention period but the control group showed no significantly gains than experimental group. An important finding from this research was that straight sprint training enhanced speed in a straight line with positive transfer to the agility tasks. Therefore, the results of this research strongly support the specificity of training.

However, sprinting, the ability to make rapid changes in direction and acceleration are important qualities sports practice [1, 2]. Perhaps because of increased quality of feedback, sprint times were faster following the program training (Table 1), in accordance with a previous investigation [4], where the 5 and 20-m sprint times of healthy young males were improved after 12 weeks of training. Tricoli et al. [14] also observed a significant improving of 10 m sprint times, but no

changes in the 30 m times of male physical education students after 8 weeks of tri-weekly weightlifting training, and two other reports also found no significant change of 30 times [15]. Such adaptations are likely a consequence of increases in leg muscle explosive power, due to improvements in motor unit synchronization, stretch-shortening cycle efficiency, and/or musculo-tendinous stiffness [15].

This study seems the first to have examined the effects of motors learning upon the agility of physical education students. The scientific literature suggests moderate to highly significant correlations between maximum relative strength and the ability to change direction rapidly [16]. The present results accord with Teo et al. [17], who noted a significant increase in the change of direction of active men after 6 weeks of strength training. Other research concerning on resistance training has shown both increases and decreases in change of direction [18, 19]. Keiner et al. [16] showed that long-term strength and conditioning improved the performance of a change of direction test. In contrast, after 6 weeks of complex training Cavaco et al. [20] found no significant changes in ball-handling agility, and Hoffman and Kang [21] reported no significant improvements in soccer players' T-test performance after 15 weeks of strength and weightlifting conditioning. Change of direction is characterized by braking and starting movements; but strength reflects muscle power. Any improvements in change of direction after strength or resistance training likely arise because of neural adaptation, particularly greater neuro-muscular coordination [22]. Repeated ability to change direction training seem task specific, and its transfer from specific tests to match play thus cannot be guaranteed.

Inter-study differences in the reported response of agility to training program reflect many factors, including test choice (length, duration, number and angle of change of direction, and requirements of running (forward or backward), the type of subjects (youth or adults, men or women, amateur or professional), and the content of the program (intensity, duration, number of sessions per week). Moreover, the performance demands of agility are not the same as strength (agility is characterized by braking and starting movements; strength is characterized by muscle power).

Limitations

This study suggests that even students of physical education who are in the initial stages of motor skill development can benefit from a self-directed climate. The present findings must be interpreted cautiously, because of the relatively small sample size and some initial differences of performance between experimental and control subjects. Further, there remains a need to extend the present observations to players of other ages and at other levels of skill, including female participants, and to analyze differences in response by playing position.

Among the limitations of our study are the short-term intervention period, and the use of only two groups. In addition, our sample size was relatively small. It was not practical to classify the participant into specific playing level and to determine performance improvements. Likewise, these facts limit the scope of the results and should be considered in the interpretation. Moreover, the total volume of training between the two groups was not controlled which could be considered as a limitation. However, this limitation does not affect interpretation of the statistically significant changes that we have observed.

Conclusion

The findings of this research indicate that straight sprint training has no limited ability to transfer to agility performance involving fast changes of direction. Therefore, the interval training and

supplementary exercises that are typically performed to enhance straight sprinting speed can be expected to be of limited value for the agility component of many sports. Coaches are advised to implement specific agility drills to develop this component. Since running mechanics are likely to vary according to the sporting situation, analysis of movement patterns typically used at high speed should be conducted. These patterns can then be incorporated into any training or testing protocols to enhance specificity.

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DETERMINANTS OF SHOOTING VELOCITY IN ELITE TEAM HANDBALL PLAYERS

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Summary

The purpose of this study was to determine the major determinants of shooting velocity for the three main shooting conditions observed in handball (standing shots, running shots and jumping shots). To this end, shooting performances were correlated (multiple regressions) to upper body (strength, anthropometrics, goniometry) and lower body (sprints and jumps) performances/characteristics. While upper body strength contributed to shooting velocity (both pushing and pulling), lower body performances did not.

Keywords: throwing performance, holistic testing, transfer, overhead throwing.

Introduction

In order to win games in handball, teams must score more goals than their opponents. Handball players score goals in a target (H=2m and L=3m) protected by a goalkeeper, 6 field players and a protected zone (6m area). Shooting velocity is therefore an important determinant of performance in handball, especially for back players (Karcher et Buchheit 2014). Shooting velocity is a complex task resulting from an interaction of multiple variable (Gorostiaga et al. 2005). Upper limb characteristics (e.g., maximal strength, power) was among the first studied factor using various exercise modalities (e.g., bench press, internal/external rotations). Previous studies showed that upper body performances were directly associated with the shooting velocity (e.g., Marques et al. 2007). The relationship between lower body and shooting velocity is more controversial with studies reporting either a relationship (Hermassi et al. 2011) or no relationship (Sabido et al. 2017). Anthropometric parameters also play a role in shooting velocity. Indeed, it was showed that general body dimensions (Debanne et Laffaye 2011) and hand dimensions (Visnapuu et Jürimäe 2007) partially determine shooting velocity. Range of motion of the glenohumeral complex seems not to contribute to throwing velocity (van den Tillaar 2016) despite their injury prevention attributes. It is worth noting that the majority of the work in shooting velocity were performed in interventional studies with a heterogeneous population with disparate training experience, which make it more difficult to conclude. Thus, this pilot cross-sectional study aimed to explore the upper and lower body determinants of shooting velocity (i.e. muscle strength, anthropometrics and range of movement characteristics).

Methods

Subjects: We measured the upper and lower body performances of 12 elite young handball players (17.4±2.9 years, 188.1±8,6 cm, 81.9±13,5 kg). All the players belong to a training center (circa 12 hours of training per week) and were selected for their ability to reach the professional level. Five of them were international young players.

Materials: Devices used for the study are presented in table 1.

Table 1: List of the materials and device used in the study.

Variable Tested		Device used
Shots		Radar Gun (Stalker Pro II, Richardson, Texas, United states)
Lower-body	Speed 10m	Optojump next 10m (Microgate, Bolsana, Italy)
	Jump	10m sprints Witty cells (Microgate, Bolsana, Italy)
Goniometry		Optojump Next 5m and 1m (Microgate, Bolsana, Italy) => horizontal and vertical jump
Upper strength and velocity		Protractor, electronic goniometer, Jadeshay, Shenzhen, China
body and		Velocity based device (Gymaware, Canberra, Australia)
		Grip strength dynamometer TKK 5401 Takei Scientific Instruments, Tokyo, Japan
		Hand-held Manual Muscle system, Lafayette instrument, (Loughborough, United Kingdom)
Anthropometry		Caliper, Mituyo, (Neuss, Germany)
		Vernier Caliper Nib Style Jaw, Mituyo, (Roissy, France)

Statistics: To assess relations between velocities and performance determinants, we calculated the Pearson's correlation coefficient between each variable and the three types of shots. We interpreted correlations using the Hopkins's scale. The variable with the higher correlation coefficient ($r > 0.5$) was used to build multiple linear regressions. We also built multiple regression model using the higher correlation coefficient.

Results

Table 2 shows the result for each variable as mean, standard deviation and coefficient of variation. Correlation coefficients above 0.5 are shown in Figure 2. Standing shot velocities were largely correlated to height, weight, hand length and arm length. We did not find any substantial relation in the lower body and mobility variables but large and very large relations exist between maximal bench pull (BPL) and bench press (BPR) strength and low load maximal velocity in BPL and BPR, respectively. Run-up shots velocities were largely related to body mass index, hand span, dominant leg counter movement jump height, maximal strength and very largely to low load maximal velocity in BPL and BPR. Jump shot velocities were largely correlated to body mass index, weight, hand span, sprinting speed and low load maximal velocity in BPL were largely and very largely associated to maximal strength in BPL and BPR, respectively.

Table 2

		Variable	Mean SD - CV		Variable	Mean SD - CV
Shots		Standing (km.h ⁻¹)	90,5±3,18 -	Goniometry	Dominant arm range of	133,±24,4 -
		Run-up (km.h ⁻¹)	99,3±4,75 - 4,7%		Non-dominant arm range of motion (deg)	174,±19,9 - 11,%
		Jump (km.h ⁻¹)	92,0±5,58 - 6,0%		Glenohumeral internal rotation deficit (deg)	-8,2±10,5 - 12%
Lower-body	Speed	Third step Velocity	21,9±0,84 -	Upper body strength and velocity	1 RM Bench press (kg)	77,6±12,1 -
		5 step maximal Speed (km.h ⁻¹)	25,4±1,14 - 4,4%		Maximal bench pull speed 30kg (m.s ⁻¹)	1,28±0,11 - 8,7%
		10m (sec.)	1,83±6,33 - 3,4%		Dominant arm isometric grip strength (kg)	53,2±6,42 - 12,%
		Acceleration (m.s ⁻²)	3,09±0,45 - 14,%		Bench press / bench pull ratio	0,98±0,09 - 10,%
	Jump	2 legs horizontal jump (cm)	253,±16,6 - 6,5%		Maximal isometric external rotational strength (kg)	19,7±3,16 - 16,%
		Dominant horizontal jump (cm)	236±15,9 - 6,7%		Maximal isometric internal rotational strength (kg)	20,6±2,59 - 12,%
		Non-dominant leg horizontal jump (cm)	234±11,6 - 4,9%		Internal rotational strength ratio	1,05±0,09 - 8,8%
		2 legs horizontal triple jump (cm)	769±40,6 - 5,2%		Maximal bench press speed 30kg (m.s ⁻¹)	1,44±0,15 - 10,%
		1 non-dominant leg horizontal triple jump (cm)	689±31 - 4,4%		1 RM Bench pull (kg)	76,7±13,3 - 17,%
		1 dominant leg horizontal triple jump (cm)	707±40,6 - 5,7%		Hand span (cm)	22,1±1,10 - 4,9%
		Drop Jump (cm)	43±5,4 - 12,%		Fore arm length (cm)	30,3±1,55 - 5,1%
		Non-dominant leg drop jump (cm)	30,1±2,94 - 9,7%		Hand length (cm)	17,5±1 - 5,7%
		Dominant leg drop jump (cm)	30,8±3,4 - 11,%		Arm length (cm)	34,5±1,91 - 5,5%
		Goniometry	Dominant arm external rotation (deg)		67,4±12,7 - 18,%	Anthropometry
Dominant arm internal rotation (deg)	66,1±11,7 - 17,%		Arm / forearm ratio	1,13±0,01 - 1,7%		
Non-dominant arm external rotation (deg)	99,7±6,83 - 6,8%		Arm / hand ratio	1,97±0,10 - 5,2%		
Non-dominant arm internal rotation (deg)	74,3±17,8 - 24,%					

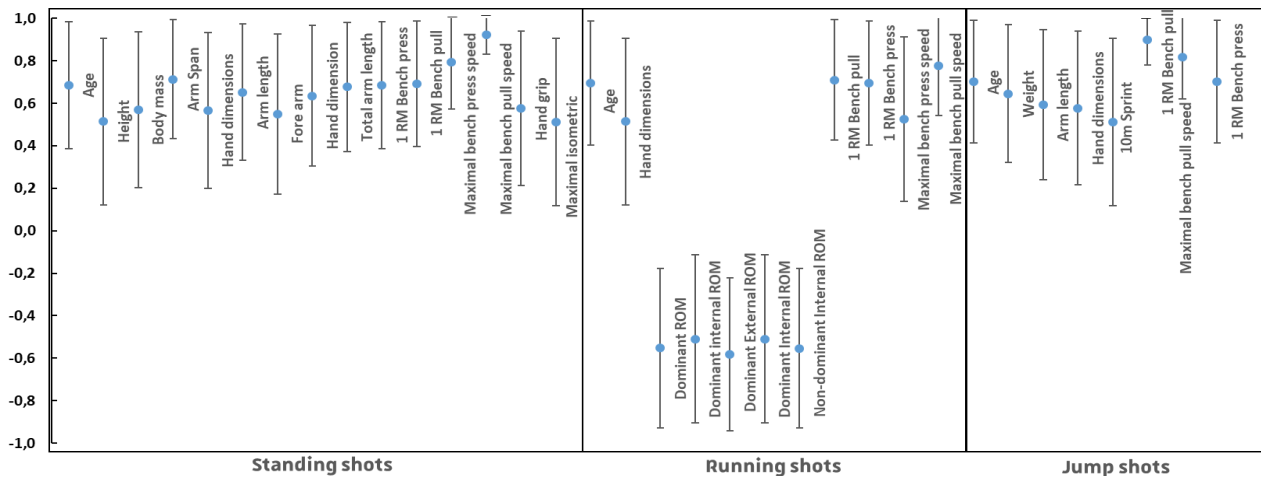


Figure 1: Values are presented as r magnitudes with 90% confidence correlations (>0,5) between standing, run-up and jump maximal shooting velocity and the different determinants. We interpreted correlations using the Hopkins's scale. The variable with the higher correlation coefficient (r>0.5) was used to build multiple linear regressions.

Table 3: The best multiple logistic regression equation in the standing shots (SS), the running shots (RS) and the Jumping shots (JS). BM stands for bodymass, ARL for arm length, Vmax for best time in the 10m sprint, ROM-D for the total range of motion of the dominant arm, BP for the 1RM bench press, BPL for the 1RM in the bench pull.

Shots	Multiple logistic regression equation	Multiple R	R square	Adjusted R square	P-Value
SS	=50.8633+BM(-0.2008)+ARL(1.3763)+Vmax(-0.5778)+ROM-D(-0.0227)+BP(0.3114)+BPL(-0.1073)	0.87	0.76	0.48	P<0.05
RS	=60.7866+ARL(-1.07)+Vmax(6.8697)+BPL(0.3488)	0.83	0.69	0.58	P<0.05
RS	=78.0908+BP(0.1648)+BPL(0.1074)	0.71	0.5	0.39	P<0.05
JS	=67.1236+BP(-0.0172)+BPL (0.3324)	0.8	0.65	0.57	P<0.05
JS	=9.9521+BM(-0.04597)+ARL(0.0807)+Vmax(7.458)+BP(0.1387)+BPL(0.25)	0.91	0.83	0.7	P<0.05
JS	=19.17+ARL(-0.1024)+Vmax(6.9742)+BPL(0.3483)	0.9	0.82	0.75	P<0.05

Table 3 contains the best multiple regression model. Using a multiple regression analysis we did not find any significant model to predict standing shot velocities based on anthropometric, lower body and mobility variables, when combined together. For standing shots, maximal BPL and BPR strengths explained 47% of the variance but none of these parameters were significant when assessed individually. Maximal BPL and BPR strength explained 50% of the variance in standing shot velocities. When mixed parameter were used arm span, sprinting speed and maximal strength in BPL explained 69% of the variance. Maximal strength maximal BPL and BPR explained 65% of the variance of the jump shot velocities. Weight, arm length, sprinting speed (p<0.05), maximal strength in BPL (p>0.05) and BPR explained 83% of the variance.

Conclusions

Our results showed that if upper body strength plays a major role in shooting velocity, it appears that the relative contribution of bench pull vs bench press performances is similar for shooting velocity. However, lower body strength appears not to be an important determinant of shooting velocity, which is in contrast with prior findings (Hermassi et al., 2011) but confirm the result from Sabido et al. (2017). It is likely that force transmission from the lower body to the upper body (likely through the core musculature) could explain these conflicting results, as players with poor core control may fail to transmit legs velocity and power to the shots. Interestingly, previous training studies found that core muscles training enhances shooting velocities ((Saeterbakken, van den Tillaar, et Seiler 2011; Manchado et al. 2017).

This study also showed that shooting velocity is related differently (i.e. specific) for each type of throw. While standing shots are determined by many factor, running shots are mostly linked to range of movement and arm strength, jumping shots are mainly determined by arm strength.

The reduction of the correlation index in the face of the increase in the complexity of the task (i.e. from standing to jumping shots) suggests an increasing number of key determinants when the level of coordination needed for the shoot is greater. Multiple regression equations revealed that shooting velocity in handball is a complex task with the contribution of anthropometrics, range of motion and physical components.

Further studies should focus on the assessment of the strength of the core muscles to get a more comprehensive understanding of the determinants of the shooting velocity in handball. Moreover, increasing the sample size of the studies is one way to confirm tendencies found in this pilot study. We should also consider focusing more on the back players as they are shooting more and from a longer distance comparing all the other players.

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EFFECTS OF BLOCKING ON DEFENSE PERFORMANCE IN BEACHHANDBALL

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Summary

This study investigated if blocking is a crucial factor of success in beachhandball. To this end, a video analysis of the Men's European Beachhandball Championship 2017 was conducted. Blocking improved the defense success rate for all shots, spin shots, specialist throws, and goalkeeper throws, while the absence reduced the defense success rate for all shots, spin shots, inflight throws, and one point throws. Thus, blocking could be an important factor for success.

Keywords: beachhandball, defense, blocking, spin shot, performance

Introduction

Beachhandball is a fast-growing sport and is part of the Youth Olympic Games (Zapardiel, 2018). The sport originated in Italy in 1990 (Bebetsos, 2012). From its beginning until now the game has changed a lot (cf. Bebetsos, 2012; Zapardiel, 2018). This includes some changes to the rules, although since 2010 the rules have not been modified any further (IHF, 2010). Therefore, is it necessary to investigate the development of the technical and tactical behavior of players over the years as well as the characteristics of successful performance. In beachhandball the defense consists of three players and a goalkeeper trying to prevent the four opposing attackers from scoring. Zapardiel (2018) mentioned that the four best teams of the Men's European Beachhandball Championship 2017 had significantly higher percentages of goalkeeper saves compared to the other teams. On average the male teams' goalkeeper effectivity was 30.21%. In comparison, the finalists had an effectivity of goalkeeper saves between 35% and 36% and the quarter finalists between 28% and 29%. In his analysis Zapardiel (2018) included direct blocks of the defense players into the category of goalkeeper saves, which does not allow an evaluation of whether the goalkeeper performance level is an inevitable factor of success or whether defense players' blocking performance equally determines success; thus, from this analysis it is not clear whether the use of a block improves the defense performance. In our opinion defense performance is an interaction between the goalkeeper and the defense players, so that the presence of a block helps the goalkeeper to save the ball. In this study the defense performance was measured as the percentage of successfully preventing the attackers from scoring a goal and was labeled as "defense success rate". Another crucial factor for top performance in beachhandball seems to be the spin shot effectiveness (Zapardiel, 2018). The current study examined if blocking leads to a better defense success rate. It is predicted that the finalists (the best four teams) of the European Beachhandball Championship 2017 had an enhanced defense

success rate in blocking situations compared to the quarter finalists. In respect of the current literature, the blocking of spin shots assumed to be a crucial factor for the success of the finalists.

Methods

In this study a quantitative video analysis of 23 games of the Men's European Beachhandball Championship 2017 in Zargeb (two quarterfinals, two semifinals, the final, the game for third place, four main round games, ten group games, and three placement round games) was conducted. The video analysis was restricted to these games because of the lack of video data from the other games. The video analysis included 14 different nations (Serbia, Croatia, Norway, Sweden, France, Switzerland, Ukraine, Germany, Denmark, Spain, Poland, Netherlands, Russia, and Hungary). Eight categories of throws/shots were identified and differentiated: spin shot (near the 6m line without a defense player between the attacker and the 6m line at the moment of the jump), faraway spin shot (from a defense position after an interception/goalkeeper save), backcourt spin shot (with an defense player between the attacker and the 6m line at the moment of the jump), inflight throw, specialist throw, goalkeeper throw, 6m, and the one point throw. In addition, the presence of a block (yes, no), regardless of whether the block was direct or not, and scoring (goal, no goal) were observed. Ten throws had to be excluded from analyses because of a restricted view. Data were analyzed using a χ^2 -Test. Reporting effect-sizes, Φ was calculated.

Results

Across the 1.464 analyzed throwing actions an average defense success rate of 36.54% was found. Because in 6m penalty situations ($n = 84$, 21.43% saving rate) no blocking is possible, these throwing actions were excluded from the analyses. Thus, a defense success rate of 41.60%, with a frequency distribution of 863 goals and 517 missed shots, was used as a base rate (BR) for the defense success rate (Fig. 1). The other throwing categories were compared to the BR, and the effectivity of blocking was analyzed.

We observed a total of 461 blocks, leading to a small but visible increase in the defense success rate in the presence of a block, that is to 48.16%, $\chi^2(1) = 8.15$, $p < .00$, $\Phi = .09$, compared to the BR, and a significantly decreased defense success rate of 32.10% without a block, $\chi^2(1) = 34.19$, $p < .00$, $\Phi = .05$, compared to the BR.

For spin shots ($n = 750$) the defense success rate was 38.40%. The defense success rate for spin shots differ just slightly from the BR, $\chi^2(1) = 3.16$, $p = .07$, $\Phi = .01$. Blocking ($n = 315$) increased the success rate, while the absence of a block decreased the defense success rate (Fig. 1).

The defense success rate for inflight throws ($n = 309$) was 35.28%. which differ slightly from the BR, $\chi^2(1) = 5.08$, $p = .02$, $\Phi = .02$. A block was used for only 37 of the inflight throws, but showed no effect compared to the BR; for inflight throws without a block, the success rate decreased significantly (Fig. 1).

In the analysis 133 one point attempts showed an average defense success rate of 27.82%. This indicates a significant lower success of defending compared to the BR, $\chi^2(1) = 10.39$, $p < .00$, $\Phi = .06$. The presence of a block ($n = 18$) showed a visible, but statistically irrelevant, effect compared to the BR. Nevertheless, the defense success rate decreased significantly in the absence of a block (Fig. 1).

The specialist throw was observed 93 times, and the mean defense success rate was 47.31%, which was similar to the BR, $\chi^2(1) = 1.24, p = .26, \Phi = .05$. Blocking ($n = 55$) increased the defense success rate significantly compared to the BR, whereas the absence of a block reduced the rate, even though this effect was just small (Fig. 1).

Throws of the goalkeepers ($n = 77$) had a defense success rate of 44.16%. This defense success rate for goalkeeper throws was similar to the BR, $\chi^2(1) = 0.20, p = .64, \Phi = .03$. Blocking ($n = 27$) improved the defense success rate compared to the BR, whereas the absence of a block had no significant effect on the defense success rate (Fig. 1).

Just four faraway spin shots were performed (one with a successful block, three without a block and one of those three with a save), and 10 backcourt spin shots were performed with a defense success rate of 30%. A block was conducted in eight cases leading to two successful defense actions; further, one of the two actions without a block was successful. Due to the low frequencies of the last two shot types (i.e., faraway spin shot and backcourt spin shot) we forwent statistical analyses of these two categories.

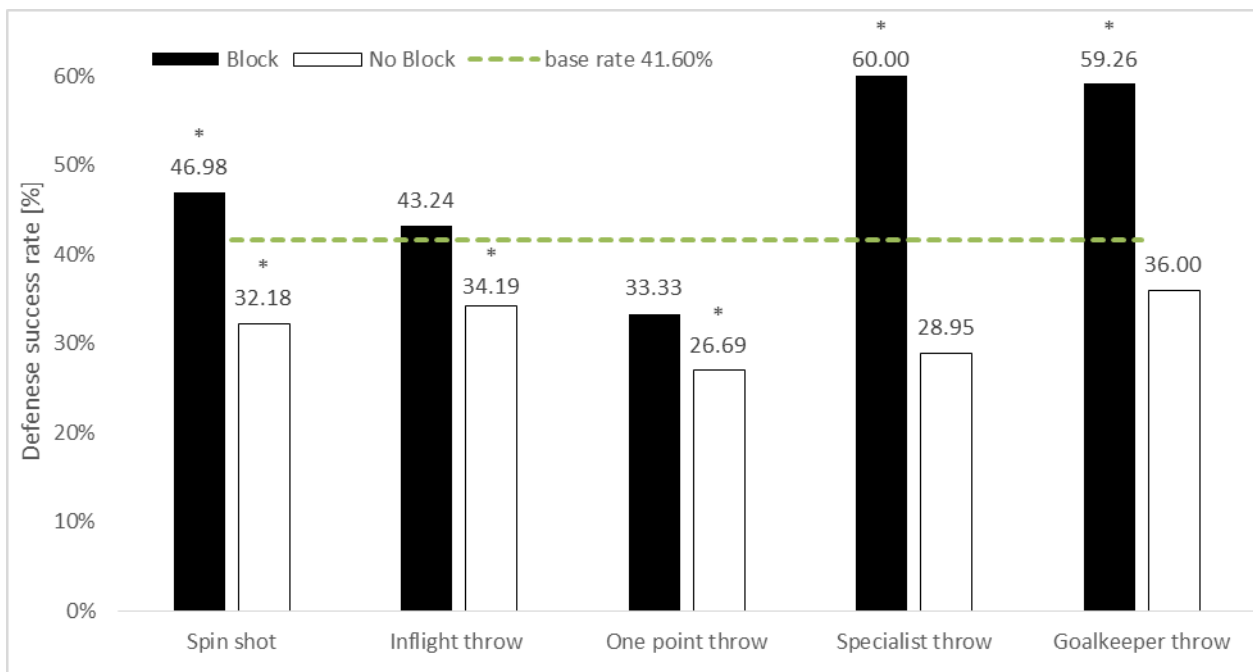


Figure 1: Defense success rates (%) against different throwing actions. The dotted line represents the base rate of the defense success rate in this study. * indicates a significant difference compared to the base rate with all χ^2 s > 3.46 , all p s $< .05$, all $\Phi > .02$. All values without * χ^2 s < 3.46 , all p s $> .05$, all $\Phi < .02$

Comparison of defense performances of finalists and quarterfinalists

For the finalists (Spain, Russia, Croatia, and Hungary) the defense success rate across all 588 observed throwing actions was 34.56%, and therefore, lower but not significantly different from the BR, $\chi^2(1) = 0.30, p = .58, \Phi = .02$. The defense success rate significantly increased with a block ($n = 237$), and decreased significantly in the absence of a block (Fig. 2).

The average defense success rate of the quarterfinalists (Norway, Ukraine, Sweden, and Denmark) across the 348 observed throwing actions was 34.77%. This was significantly lower than the BR, $\chi^2(1) = 6.68, p = .00, \Phi = .02$. The defense success rate was similar to the BR in the presence of a block, whereas it was significantly reduced in the absence of blocking (Fig. 2).

For spin shots ($n = 346$) the finalists' average defense success rate (40.72%) was nearly equal to the BR, $\chi^2(1) = 0.11, p = .73, \Phi = .00$. A significant higher defense success rate was found in situations a block ($n = 174$) was used by the defense compared to BR, whereas the absence impaired the defense success rate (Fig. 2).

The quarter finalists' defense success rate for defending spin shots ($n = 198$) was 37.26%, and thereby close to the BR, $\chi^2(1) = 1.45, p = .22, \Phi = .00$. With a block ($n = 62$) the success rate increased, but did not differ significantly from the BR. Without a block the defense success rate decreased significantly compared to the BR (Fig. 2).

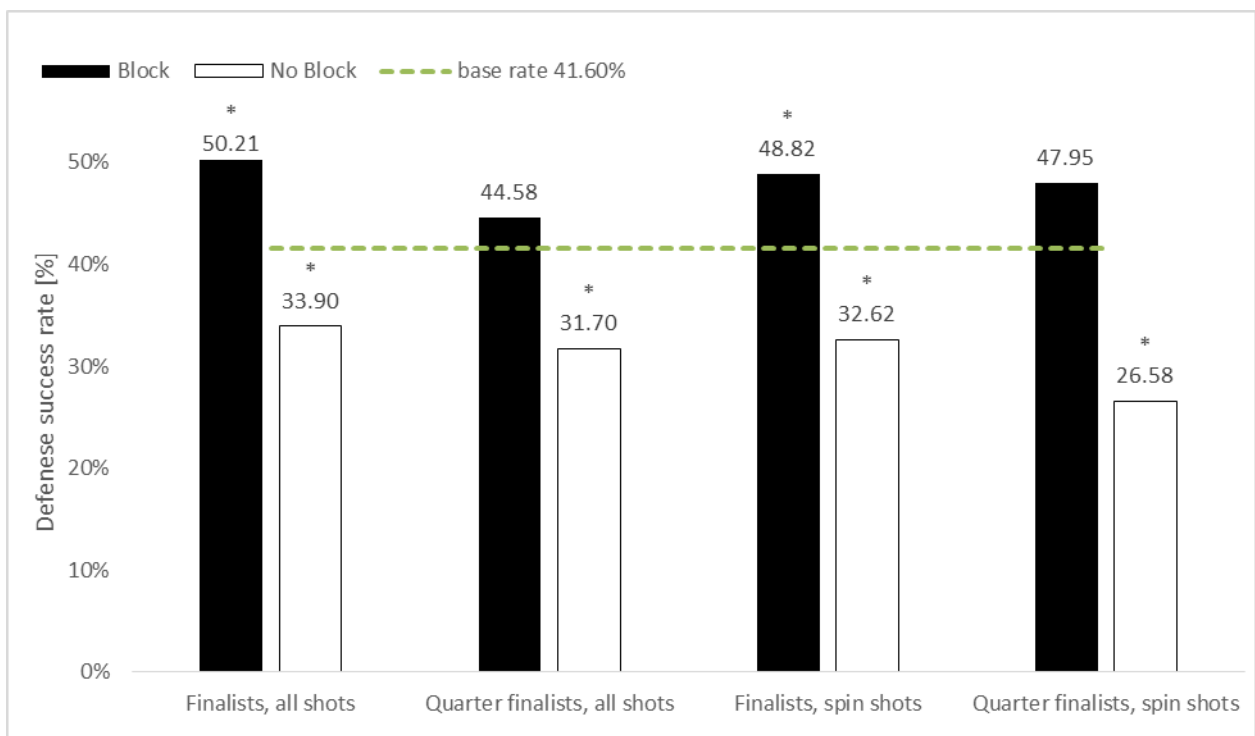


Figure 2: Defense success rates (%) of the finalists and quarterfinalists against all shots and against spin shots specifically. The dotted line represents the base rate of the defense success rate in this study. * indicates a significant difference compared to the base rate with all χ^2 s > 3.38, all p s < .05, all Φ > .02. All values without * χ^2 s < 3.46, all p s > .05, all Φ < .02

Before discussing these results of the finalists, we have to keep in mind that due to the differing availability of video data, the number of the analyzed matches was not equal with regard to the competing nations (Spain = 4 matches, Russia = 2, Croatia = 7, Hungary = 3, Norway = 5, Ukraine = 1, Sweden = 4, and Denmark = 1).

Discussion

We predicted that blocking improves the defense success rate. The results showed that in general the defensive performance was significantly improved by the presence of a block and significantly decreased by the absence of a block. For spin shots it was observed that blocking leads to a significant enhancement of the defense success rate, whereas the defense success rate was significantly lower without a block, compared to the base rate. When no block was present for one point throws the defense success rate decreased significantly. In addition, for specialist throws and goalkeeper throws the presence of a block led to a significant improvement, while the absence of a block in these situations did not lead to significant changes in defense performance compared to the base rate. All things considered, blocking has proven to be an important factor for the improvement of the defense success rate in Men's beachhandball.

Moreover, we assumed that the finalists had a better defense success rate for blocking actions compared to the quarterfinalists. The finalists' defense success rate was significantly higher for blocking actions and lower for no blocking actions compared to the base rate. In contrast, the quarter finalists' defense success rate did not improve in the presence of a block. It did however decrease significantly in the absence of a block. Comparing the average defense success rates of the finalists and the quarterfinalists these rates are nearly equal. Considering Zapardiel (2018), who found significant differences between the defense performances of these two groups, the fact that in the present study no difference was found could be explained by the smaller number of analyzed games in this study due to the lack of video data. In addition, the defense success rate of the Russian team was low compared to the other finalists, which clearly decreased the finalists' mean defense success rate. In conclusion, we did not find a higher defense success rate for the finalists compared to the quarterfinalists. However, we do assume the finalists had a better blocking performance because of the significant improvement for all shots and the spin shots compared to the base rate that was achieved in this group by blocking, which was not found for the quarterfinalists.

We furthermore assumed that blocking spin shots is a crucial factor for success. As mentioned above, the defense success rate against spin shots was significantly improved for the finalists in the presence of a block, but not for the quarterfinalists. For both groups the defense success rate decreased significantly without a block. It is further worth mentioning that the finalists' defense success rate without a block was 6% higher compared to the quarterfinalists' defense success rate, which could be explained by a higher goalkeeper performance level, that might also be a factor of distinction between these groups. In summary, Zapardiel (2018) assumed that spin shot performance is one of the most important factors for successful game performance. Blocking improved the defense success rate and the absence of a block decreased it, which could lead to the assumption that blocking is a key factor for success in beachhandball, when used to defend spin shots.

In conclusion, blocking is an important factor for increasing the defense success rate in beachhandball. A distinction between finalists and quarterfinalists may be the finalists' better blocking technique because of the significant improvement of the defense success rate against all shots they achieved by blocking compared to the base rate, which was not observed for the quarterfinalists. The same pattern can be seen for the defense performance against spin shots, which is especially relevant, because according to Zapardiel (2018) the spin shot performance is

a crucial factor for top performance in beachhandball. Based on the current results, we conclude that blocking performance is an(other) crucial factor for success in beachhandball. Yet, it must be mentioned that we could only report small effect sizes for all current results.

Further research should investigate in which situations and positions a block enhances the defense success rate and in which situations a block is not necessary, and therefore, the team's focus should be on the fast break. Additionally, a greater number of games should be analyzed to gain more knowledge about whether blocking is a distinctive feature of successful in contrast to less successful teams, or whether the performance level of the goalkeeper plays a more important role. Furthermore, the success rate of different kinds of blocks, like diver block or double block, should be examined.

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LOAD PARAMETERS ASSOCIATED WITH QATCH MATCHES USING MICROSENSOR TECHNOLOGY

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Summary

The aim of this study was to measure the external and cardiovascular load during 4 Qatch matches using microsensor technology and compare it with previous results measured during team handball. The number of high-intensity events/minute was lower than in team handball (especially decelerations/minute), similarly to the cardiovascular load. The physical demands of Qatch are similar but somewhat lower than those of team handball.

Keywords: Qatch, team handball, external load, cardiovascular load

Introduction

Overview of the rules. Qatch is originated from various ball games including handball and is played on the Teqball table. There is a hexagon shaped line system consisting of baselines and sidelines. In this game, two teams of three players throw the ball back and forth to each other in an intense manner. Two players from the same team are at the same end of the table while the third player, the defender is at the opposite end among their opponents (Figure 1.). The defender starts the game with the opening throw by passing the ball to his teammates and it has to bounce once on the table before being caught by a teammate. During the opening throw the opposing players have to stay outside the hexagon, till the ball has been caught by the opponent. The opening throw alternates between the teams after every second valid rally. A minimum of 1 pass is required between teammates before returning the ball. Each team has a maximum of 3 passes to return the ball. Players are not allowed to dribble the ball. Bounce pass is allowed using the floor or the table. Players are allowed to hold the ball for maximum 3 seconds. Players are allowed to touch the ball with any body part including the legs as long as the ball has been thrown by the opponent. When returning the ball, the ball must bounce on the opponent's playing side of the table. Once the ball is returned, the defender must leave the hexagon and go back to the baseline using the fastest route without blocking the opponent. Whilst returning the ball the thrower is not allowed to touch or cross the lines of the hexagon with any body part. Players are not allowed to land on or inside the lines of the hexagon after returning the ball unless it is an air shot. In that case landing on or inside the hexagon is allowed. Whilst returning the ball players are not allowed to touch or cross the centre line with any body part. In case of an infringement of any of these rules the team of the player that committed the foul receives a penalty point. If a team receives two penalty points in a game, the opposite team is awarded a penalty throw. During the penalty throw the thrower stands behind any of the sidelines and executes a direct shot on the table. Only one player from the opposing team is allowed to try to catch the ball. If the defending player catches the ball the play continues. If the defending player does not catch the ball and it hits the ground after it has hit the table, a point is awarded to the team that executed the penalty throw. If the thrower misses the penalty throw, no point is awarded and the play continues as normal. If the ball touches the edge of the table, the rally must be replayed. If the ball hits the side of the table (side ball) after a throw has been executed, the point is awarded to the opposing team. The "doublepoint" offers the opportunity for the teams to score two points instead of one in a single rally. The "doublepoint" can only be requested by a team once per set. It needs to be requested before the start of the rally. After every four valid

rally the defenders need to be changed based on the rotating system. After each game teams need to change ends. A match is won by winning one or more sets based on the respective competition format. A set consists of two winning games. A game is won when a team reaches 8 points.

Aim of the study. As Qatch is a new and developing game, little is known about the physical demands of it. As the rules are adapted from team handball, we were investigating whether the external and cardiovascular load are comparable to those measured previously in team handball using microsensor technology.

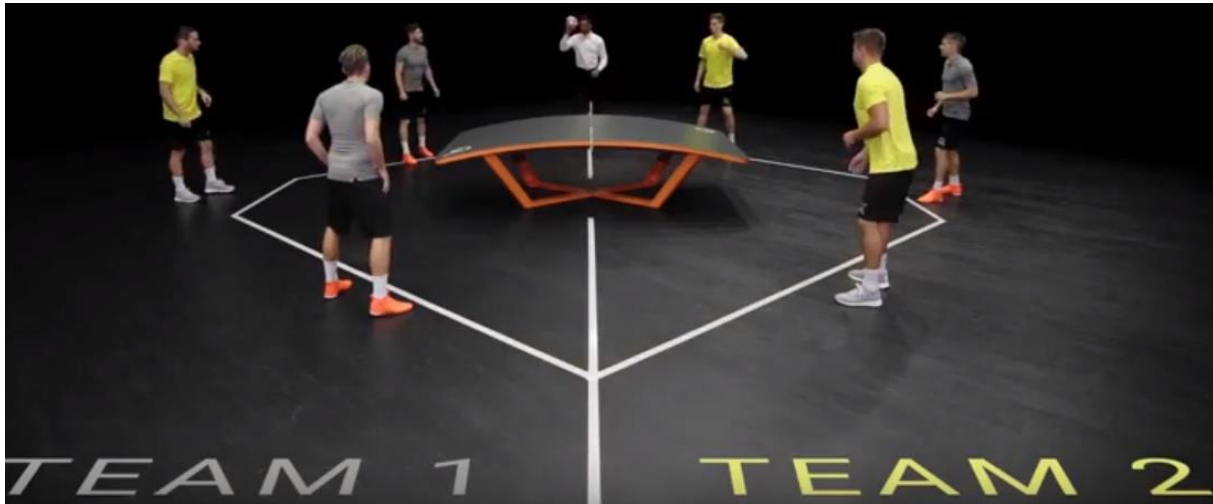


Figure 1. Setup of Qatch before starting the game.

Methods

Subjects. Six physically active men took part in this study (age: $24,2 \pm 3$ years, height: 179 ± 4 cm, weight: 74 ± 6 kg). They were informed about the experimental design and gave their written consent to take part in the study.

Experimental overview. The players were invited to play 2 Qatch matches on two consecutive days in an indoor environment. After a standardised warm-up the two teams played two matches with one hour rest in-between. Each match consisted of two sets, each set broken down to three games. There was a 1-minute rest between the games and a 5-minute rest between the sets.

External load measurement. During matches, the players were equipped with a specially designed microsensor between the shoulder blades in a custom-made vest located under the jersey (Catapult T6, Catapultsports, Australia). Catapult T6 is an indoor local positioning system, using anchor nodes to determine the actual position of the players and provide locomotive data (total distance, high intensity distance, sprint distance, maximal velocity etc.). As Qatch is played in a very small area, we assumed that the locomotive load experienced by the players would be minimal, therefore we used the system without anchor nodes. In this case, the in-built microsensors (accelerometer, gyroscope, magnetometer) provide useful information about the mechanical load of the players at 100 Hz sampling frequency. By combining the information provided by the three microsensors, the unit orientation and direction can be determined, therefore high-intensity micromovements (accelerations, decelerations, changes of directions) can be captured. The start and end times of each games were recorded and based on that the rest periods have been excluded in Catapult Openfield Console software.

Data processing of external load measurement. Player Load™, accelerations (Acc), decelerations (Dec) and left/right changes of directions (CoD) were exported from Catapult Openfield Cloud using Inertial Movement Analysis (IMA). Player Load is derived from the

accelerometer along the three axes (anterior-posterior, medio-lateral, upside-down) and characterises the overall workload of the player (Catapult, 2013). Player LoadTM is calculated as an instantaneous rate of change along the three axes and divided by 100 (Boyd et al., 2011). After integrating the raw microsensor data, Openfield uses an advanced Kalman filter to subtract the effect of gravity. Based on the direction of force applied the micromovements are categorized as accelerations (Acc), Decelerations (Dec), left or right changes of directions (Cod Left, Cod Right). Based on the change of velocity (m/s) the Acc, Dec and Cod have been categorised as low (1,5-2,5 m/s), medium (2,5-3,5 m/s) and high-intensity (>3,5 m/s) events. To ensure higher reliability, according to previous research medium and high intensity event counts have been taken together (Luteberget et al., 2018). According to this reliability study, the coefficient of variation for Player LoadTM was 0,9 %, for the IMA directions categorised into bands were between 2,9-5,6 %. Results are shown as mean±standard deviation.

Internal load. Maximal heart rate of the players has been determined during a 15 m shuttle test, in which the players had to run until volitional fatigue. Polar Team2 (Polar, Finland) heart rate belt were used to measure heart rate during the test. The maximal heart rate has been determined individually using the last stage of the shuttle run test. The maximal heart rate was 195 ± 1 bmp. In addition, mean heart rate (HR_{mean}) as absolute value and percentage of the individual maximal heart rate was determined during Qatch matches. In addition, percentage of time spent in different heart rate zones based on maximal heart rate was also examined. Capillary blood lactate (mMol/L) was measured from the fingertip before the start, during the half time and two minutes after the end of each match using a portable analyser (Lactate Scout+, EKF Diagnostics).

Results

External load during Qatch matches.

Table 1. Average values of the accelerations, decelerations, changes of directions, jumps and high-intensity events for the players during the matches. Acc Med+High: the number of accelerations >2,5 m/s, Dec Med+High: the number of decelerations >2,5 m/s, Cod Left Med+High: the number of left changes of directions >2,5 m/s, Cod Right Med+High: the number of right changes of directions >2,5 m/s, Jump Med+High: the number of jumps >20 cm. HIE: high intensity events, the sum of accelerations, decelerations, left and right changes of directions.

	Duration	Acc Med+High	Dec Med+High	Cod Left Med+High	Cod Right Med+High	Jump Med+High	HIE
Match1	0:31:21	25,50	23,67	24,17	21,33	13,17	94,67
Match2	0:34:27	28,33	23,33	24,50	20,33	14,83	96,50
Match3	0:32:04	24,00	24,00	23,00	17,83	16,67	88,83
Match4	0:39:11	24,83	23,50	24,17	17,83	18,83	90,33
Average	0:34:16	25,67	23,63	23,96	19,33	15,88	92,58
SD	0:03:32	1,88	0,28	0,66	1,78	2,44	3,60

Table 2. Average values of the accelerations, decelerations, changes of directions and jumps for the players during the matches normalized to net playing time. Acc Med+High/min: the number of accelerations >2,5 m/s per minute, Dec Med+High/min: the number of decelerations >2,5 m/s per minute, Cod Left Med+High/min: the number of left changes of directions >2,5 m/s per minute, Cod Right Med+High/min: the number of right changes of directions >2,5 m/s per minute, Jump Med+High/min: the number of jumps >20 cm per minute. HIE/min: high intensity events per minute, the sum of accelerations, decelerations, left and right changes of directions per minute.

	Duration	Acc Med+High/min	Dec Med+High/min	Cod Left Med+High/min	Cod Right Med+High/min	Jump Med+High/min	HIE/min
Match1	0:31:21	0,82	0,76	0,77	0,68	0,42	3,03
Match2	0:34:27	0,82	0,68	0,71	0,59	0,43	2,80
Match3	0:32:04	0,75	0,75	0,77	0,56	0,52	2,77
Match4	0:39:11	0,63	0,60	0,62	0,46	0,48	2,31
Average	0:34:16	0,76	0,70	0,72	0,57	0,46	2,73
SD	0:03:32	0,09	0,07	0,07	0,09	0,05	0,30

Internal load during the matches. During the games one player did not have any heart rate data, therefore the internal load could be determined for 5 players only. The average heart rate during Qatch was 145 ± 15 bpm, which is $74 \pm 7,5$ % of the individual maximal heart rate of the players. The percentage of time spent in different heart rate zones are shown in Table 3. Lactate values are shown in Table 4.

Table 3. Percentage of total net playing time spent in different heart rate zones based on the individual maximal heart rate determined during a field test. e.g. % in HR_{max} 45-55 %: % of total playing time spent between 45-55 % of individual maximum heart rate.

	% in HRmax 45-55 %	% in HRmax 55-65 %	% in HRmax 65-75 %	% in HRmax 75-85 %	% in HRmax 85-95 %	% in HRmax 95-100 %
Match1	9	9	20	25	28	1
Match2	4	15	21	34	26	0
Match3	2	16	43	35	4	0
Match4	12	31	35	21	1	0
Average	6,75	17,75	29,75	28,75	14,75	0,25
SD	4,57	9,36	11,18	6,85	14,22	0,50

Table 4. Capillary blood lactate values (mMol/L) before the start of each game (Pre), in the half time (Mid) and 2 minutes after the end of the games (Post).

	Pre	Mid	Post
Match1	1,6	4,2	4,2
Match2	2,8	4,4	2,0
Match3	2,0	5,0	3,4
Match4	6,2	3,5	3,2
Average	3,2	4,3	3,2
SD	2,1	0,6	0,9

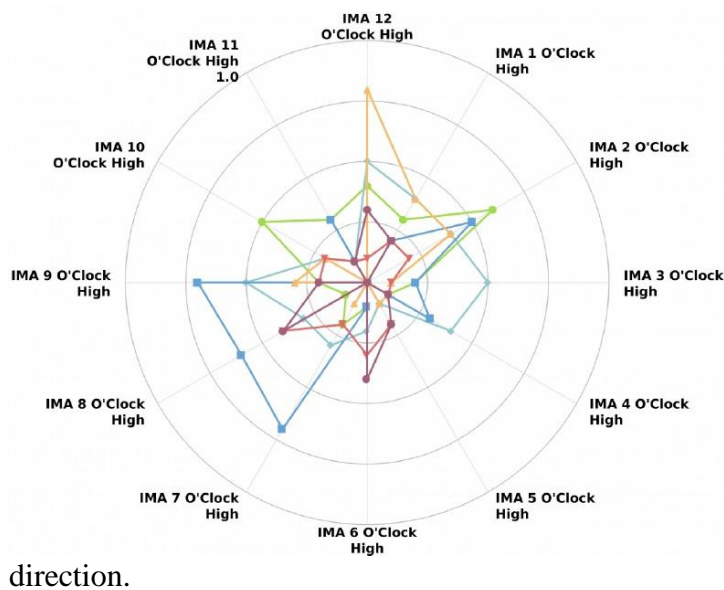


Figure 2. High intensity micromovement profile of all players during the first match. Each colour represent a different player. In this schematic view the player stands in the centre of the circle facing 12 o'clock. Anything between 10,30-1,30 o'clock will be counted as high-intensity acceleration, between 1,30-4,30 as right change of direction, between 4,30-7,30 as deceleration and between 7,30-10,30 as left changes of direction. The closer is the coloured line to the time value, the more high-intensity micromovement happened in that

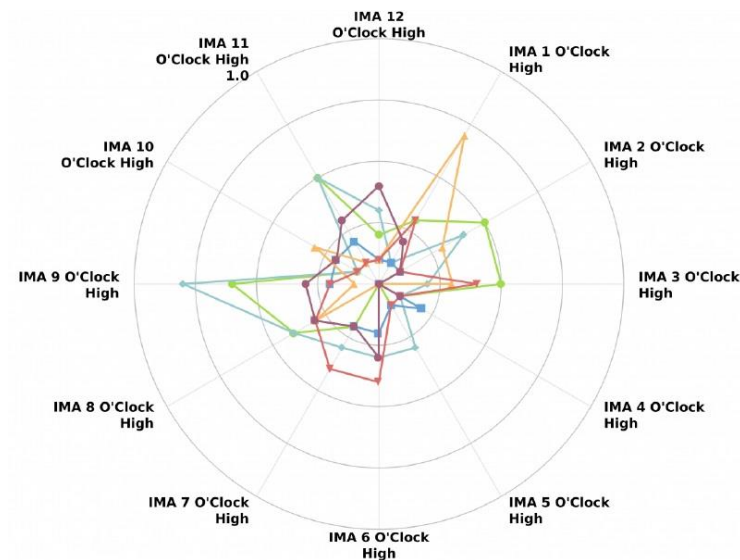


Figure 3. High intensity micromovement profile of each player during the second match on the first day. Each colour represents a different player. In this schematic view the player stands in the centre of the circle facing 12 o'clock. Anything between 10,30-1,30 o'clock will be counted as high-intensity acceleration, between 1,30-4,30 as right change of direction, between 4,30-7,30 as deceleration and between 7,30-10,30 as left changes of direction. The closer is the coloured line to the time value, the more high-intensity micromovement happened in that direction.

Discussion

To the best of our knowledge this is the first study to examine the cardiovascular and external load during Qatch matches. The main findings were: 1) HIE/min was comparable but somewhat lower than during a handball game, 2) cardiovascular load (HR_{mean} , time spent in different heart rate zones) was lower than during a handball game, 3) moderate lactate values indicate that anaerobic lactic energy system also plays a role in Qatch, although during short rallies anaerobic alactic system might be the dominant energy system.

External load. There are only a few studies using inertial sensor technology to measure the mechanical load during team handball games. This technology allows to detect short, sharp accelerations, decelerations and changes of directions, which was not possible with previous tracking technologies (Luteberget et al., 2018). Qatch players executed $2,73 \pm 0,5$ high-intensity events, which is comparable but somewhat lower than previously suggested for elite Norwegian team handball players (Luteberget and Spencer, 2017). The Norwegian team handball players

had $3,9 \pm 1,58$ HIE/min, even though their playing time was similar (33,2 min) to the net match time during Qatch.

If we examine the breakdown of the HIE, we can see that the biggest difference was in the number of decelerations per minute, as Qatch players executed a lot less from these actions than team handball players ($0,7 \pm 0,07$ vs $2,3 \pm 0,9$). This finding needs further investigation. However, one should keep in mind that the subjects in our study were recreationally active men, which might explain partly the lower number of micromovements in comparison to world-class female handball players. Positional breakdown would also be interesting, however our limited sample size did not allow enough statistical power for this comparison. Luteberget and Spencer (2017) did not report the jumping data from the microsensors. In Qatch jump data might be more applicable, as the players are not allowed to touch the opponent, therefore it is less likely to land on the opponent's feet than in team handball, which would decrease the validity of the results. Qatch players jumped $0,46 \pm 0,05$ times per minute. Most of the jumps were moderate intensity (20-40 cm), but it still emphasizes the importance of lower limb power in this sport.

Internal load. Average heart rate during Qatch was 145 ± 15 bpm equalling $74 \pm 7,5\%$ of individual maximal heart rate. Previous studies suggested, that average heart rate is between 70-86 % of individual maximum in team handball, depending on gender, age and position (Karcher and Buchheit, 2014). More importantly, it often happens that the players spend $>50\%$ of their playing time $>80\%$ of their maximal heart rate, suggesting a high aerobic demand (Karcher and Buchheit, 2014). Qatch placed lower cardiovascular demands on the players, as 58,5 % of the match time was spent between 65-85 % of individual maximal heart rate even though the average heart rate was comparable to those in team handball. We could not determine the individual anaerobic threshold of the players, but the lactate measurements suggest that the anaerobic lactic system also plays an important role during Qatch. Still we assume that due to the relatively short rallies the anaerobic alactic system might be more important during the critical moments of the game and that is why we could not measure extremely high lactate values. The contribution of the different energy systems definitely needs some further investigation to optimise the physical preparation of Qatch players. The possible high importance of the anaerobic alactic system in Qatch might be an important similarity to team handball.

Limitations and future directions. Unfortunately, our subjects were not professional handball players, therefore we could not measure their cardiovascular and external load during team handball games. This could give us a better understanding about the match load in the same individuals during team handball and Qatch matches. The variability of physical output during team sport games (soccer) has been demonstrated previously (Gregson et al., 2010), therefore our limited sample size suggest that we need to be careful with the generalization of our results. It would also be interesting to measure female players during Qatch in comparison to team handball. We did not measure the locomotive load (total distance, high intensity distance, sprint distance, maximal velocity) of the players, as due to the limited playing area there is no space for the players to reach high velocities and cover long distances. Therefore, we think that the IMA based high-intensity events better describe the load imposed on the players during Qatch.

In conclusion, Qatch might be an interesting, alternative training method/game for team handball players to enhance their sport-specific abilities. However, these hypotheses definitely need further investigations using bigger sample size.

RECREATIONAL TEAM-HANDBALL HAS POSITIVE EFFECTS ON BONE HEALTH, BODY COMPOSITION AND PHYSICAL FITNESS OF INACTIVE POSTMENOPAUSAL WOMEN

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Summary

This study analyses the effects of a 16-week recreational team handball-based programme (2-3x60min per week) on bone health, body composition and physical fitness of inactive postmenopausal women. Preliminary results show positive effects on lumbar spine bone mineral density, hip total bone mineral content, body mass, body fat, muscle strength, flexibility, agility and balance, which can counteract some menopause-related adverse effects.

Keywords: recreational team sports; bone health; body composition; physical fitness; postmenopausal women.

Introduction

Menopause is a permanent condition in women's life characterized by several adverse effects on health, mainly due to the decrease of estrogen levels (Baker et al., 2018). Estrogens play an important role on keeping the organism balanced at different levels and the decrease of this hormones leads to adverse effects on women's health, namely in body composition, cardiovascular and bone health (Attapattu et al., 2015). Exercise has proven to have a positive effect in decreasing body mass and body fat and increasing lean and bone mass, as well as improving physical fitness and functional capacity, among other benefits in this population (Attapattu et al., 2015). Notwithstanding the effectiveness of traditional modes of exercise such as aerobic, resistance and combined training, new types of exercise should be considered. A short-term intervention using floorball (Nyberg et al., 2014; Seidelin et al., 2017) resulted in positive effects on health markers of postmenopausal women, namely in fat and lean mass, maximal oxygen uptake and functional capacity (intermittent high-intensity endurance), suggesting that exercise programmes using team-sports could also be effective in this population. Recreational team-handball practice effects have already been tested in adult men and women showing encouraging results (Hornstrup et al., 2018; Hornstrup et al., 2019; Póvoas et al. 2018), though being still understudied in postmenopausal women. This study aimed to analyse the effects of a short-term recreational team handball-based programme on bone health, body composition and physical fitness of inactive postmenopausal women.

Methods

Sixty-eight postmenopausal women (68.2±6.2 years; 156.9±5.9 cm; 67.2±9.5 kg; 37.7±5.4% fat mass) were randomly allocated into team handball (THG; n=42) or control groups (CG; n=26). The THG performed a 16-week recreational team handball programme consisting of 2-3 60-min sessions per week. Each session was composed by a standardized warm-up and 3 15-min periods

of recreational team handball matches played as small-sided games. The CG participants were instructed to follow their regular daily activity. All the participants were informed verbally and in writing about the purpose, potential risks and benefits of this study and written informed consent was obtained from them all.

Participants were evaluated at the beginning and end of the 16-week exercise intervention.

Body weight and height were measured with the participants in light clothes and without shoes, following standardized protocols. Weight (0.01 kg) was measured by a digital bioimpedance scale (Tanita Inner Scan BC 532, Tokyo, Japan) and height (0.1 cm) by a portable stadiometer (Seca 213, Hamburg, Germany).

Fat mass (%), bone mineral density (BMD; g/cm^3) and bone mineral content (BMC; g) was determined by dual-energy X-ray absorptiometry (DXA; Hologic Explorer QDR, Hologic Inc., Belford, MA, USA).

Physical fitness was assessed by the following tests (Rikli & Jones, 2001): chair stand (lower body strength); arm curl (upper body strength); sit-and-reach (lower body flexibility); back scratch (upper body flexibility); up-and-go (coordination and agility). Strength tests' outcomes were reported in number of complete repetitions (n). Flexibility was measured in centimetres. Coordination and agility results were reported in seconds. Balance was assessed by a single-legged Flamingo test (Deforche et al., 2003). Heart rate (HR) was assessed during the training sessions using HR monitors (Firstbeat Technologies Ltd., version 4.5.0.2, Jyväskylä, Finland).

Statistics

Results are presented as means \pm standard deviations (SD). Baseline differences and intervention effects were analysed using a two-way repeated-measures analysis of variance (ANOVA), with Bonferroni *post hoc* procedures. Statistical Package for the Social Sciences (SPSS Inc., version 25) was used for data analysis. Statistical significance was set at $p \leq 0.05$.

Results

The participants' mean training attendance was 1.9 ± 0.4 (0.9-2.9) sessions per week, with a total average of 31 ± 7 (15-47) out of the 48 total training sessions. Mean HR was $76 \pm 6\%$ HR_{max}, with peak values of $88 \pm 6\%$ HR_{max} and for $44 \pm 20\%$ of total match duration the HR was $>80\%$ HR_{max}. The baseline and after 16-weeks results are presented in Table 1.

A time effect was shown for body mass ($p=0.002$), body fat ($p<0.001$) and lean mass ($p=0.042$). THG decreased body mass by 1.5% ($p=0.003$). Both groups decreased body fat (-2.5% and -1.7%; $p<0.001$ and $p=0.009$; THG and CG, respectively) and no differences were observed in lean mass in both groups.

For lumbar spine, a time x group interaction ($p<0.001$) was observed for BMD and BMC. A time effect ($p=0.021$) was observed for hip BMC, however no time, group or interaction effect was shown for hip BMD. THG increased lumbar spine bone mineral density (BMD) (1.5%; $p<0.001$) and bone mineral content (BMC) (2.3%; $p<0.001$), as well as hip total BMC (2.2%; $p=0.004$).

A time and group effects were observed for upper body ($p=0.002$; $p=0.003$) and lower body strength ($p<0.001$ for both effects). Additionally, a time x group interaction was also observed for lower body strength ($p=0.008$). A time effect was shown for upper and lower body flexibility and balance ($p=0.001$; $p=0.040$; $p=0.048$ respectively). For agility, a time effect ($p<0.001$) and also a group effect ($p=0.041$) was shown. Only the THG improved muscle strength (upper body: 17.5%, $p=0.001$; lower body: 26.3%, $p<0.001$), flexibility (upper body: 3.7cm, $p<0.001$; lower body: 2.6cm; $p=0.011$), agility (14.0%; $p<0.001$) and decreased the number of falls in the

postural balance test (-8.5%; $p=0.017$) comparing to baseline results. Additionally, at 16-weeks, the THG showed significant higher strength (upper body: $p=0.001$; lower body: $p<0.001$) and agility scores ($p=0.002$) than the CG.

Table 1 Body weight, body composition, bone and physical fitness markers results at baseline and after 16 weeks of small-sided recreational team handball training or a continuation of the usual lifestyle.

		THG (n=42)	CG (n=26)	Two-way ANOVA		
				Time F p	Group F P	Interaction F p
Body mass (kg)	Baseline	68.0±9.7	64.5±9.2	10.760	2.086	0.302
	16-weeks	67.0±9.4*	63.8±9.5	0.002	0.153	0.585
Body fat (%)	Baseline	41.3±5.4	40.0±6.9	23.513	0.585	0.484
	16-weeks	40.2±5.1*	39.2±6.7*	0.000	0.447	0.489
Lean mass (kg)	Baseline	37.2±4.1	35.9±3.5	4.291	1.840	0.009
	16-weeks	37.4±4.1	36.1±3.8	0.042	0.180	0.095
Lumbar spine BMD (g/cm ³)	Baseline	0.892±0.129	0.893±0.128	1.718	0.084	16.064
	16-weeks	0.905±0.130*	0.886±0.127	0.195	0.773	0.000
Lumbar spine BMC (g)	Baseline	50.1±10.1	49.1±8.3	2.224	0.628	15.266
	16-weeks	51.2±10.3*	48.6±8.2	0.141	0.431	0.000
Hip BMD (g/cm ³)	Baseline	0.883±0.101	0.819±0.114	2.229	0.317	0.104
	16-weeks	0.838±0.098	0.822±0.120	0.134	0.575	0.748
Hip BMC (g)	Baseline	25.3±3.6	25.4±4.2	5.549	0.017	1.891
	16-weeks	25.8±3.5*	25.5±4.3	0.021	0.897	0.174
Strength upper body (n)	Baseline	16.3±4.3	14.3±3.5	10.138	9.386	1.473
	16-weeks	18.5±3.4*	15.3±3.5 [#]	0.002	0.003	0.230
Strength lower body (n)	Baseline	16.0±3.3	13.8±3.8	32.954	13.735	7.599
	16-weeks	19.9±5.0*	15.2±3.9 [#]	0.000	0.000	0.008
Flexibility upper body (cm)	Baseline	-5.1±11.0	-4.4±10.5	13.044	0.044	3.179
	16-weeks	-1.4±7.7*	-3.2±11.4	0.001	0.835	0.080
Flexibility lower body (cm)	Baseline	-0.2±10.1	-0.6±11.2	4.415	0.269	1.367
	16-weeks	2.5±11.2*	0.2±9.6	0.040	0.606	0.247
Agility (s)	Baseline	5.6±1.1	5.8±1.3	25.117	4.333	7.040
	16-weeks	4.7±0.6*	5.5±1.4 [#]	0.000	0.041	0.100
Balance (n)	Baseline	39±13	36±12	4.106	0.116	1.489
	16-weeks	33±13*	34±13	0.048	0.734	0.228

* Significantly different from baseline ($p\leq0.005$).

[#] Significantly different from the team handball group ($p\leq0.005$).

BMC - Bone mineral content; BMD - Bone mineral density.

Conclusions

Preliminary results show that recreational team-handball has positive effects on weight, body composition, bone health and physical fitness of postmenopausal women. Recreational team-handball seems to be effective in improving health, body composition, and physical fitness of inactive postmenopausal women, which could counteract some of menopause-related adverse effects.

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AN APPROACH TO THE PHENOMENON OF HANDBALL PLAYERS RETENTION IN PORTUGUESE CONTEXT

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Summary

Handball has evolved alongside with consolidation of sport's culture. The present study aims to explore the retention and dropout of handball federated athletes in Portugal. Results from the survival analyses indicate a median length of stay of the athletes is two years, with an associated probability of 41% to continue more than that period. It is also evident that there is an average of 3 years of being registered as an active player.

Keywords: Handball; Portuguese Handball Federation; retention; survival analysis

Introduction

In the present context of physical activity that has gained terrain in athletes not only for the health benefits but as also as integration feelings, the Handball activity has evolved alongside with consolidation of sport's culture.

Portugal is not an exception in this profile, therefore the research question of this paper is to explore the retention and dropout of handball federated athletes in Portugal, using the data base of handball federation.

The aim of the paper is the following: First retention of handball players is of paramount importance for the sustainability of the sporting discipline.

Considering that fitting the cultural praxis of athletes' retention, and the need to improve the fit between frameworks, needs, and development of athletes, a much-needed approach to the subject is suitable. In fact, the retention, or the model within will be a model that can be "contextualized or adapted to a particular national and / or sports context, based on the empirical data (Stambulova, 2016, p. 454).

For being able to develop an approach to an athletic career, retaining athletes' is embedded in stages and transition's in various forms: athletic, academic, vocational, psychosocial, psychological, financial (Ekengren, Stambulova, Johnson, & Carlsson, 2018), and family context.

Determinants for success in sports, and the reach of the elite level have been done across sports, in recent decades. For instance, one of the common denominator for reaching the elite level, and

therefore, being retained in the sport, is the date of birth, or what is called the relative age effect (Ostapczuk and Musch, 2013). This crosses over the youth and senior level across nations and sports (Baker and Logan, 2007, Delorme and Raspaud, 2009, Helsen et al., 2012, Till et al., 2010, Schorer, Wattie, & Baker, 2013, Wrang, Niels, Rossing, Diernæs, Hansen, Dalgaard-Hansen, Karbing, 2018).

In terms of sex, literature findings point out differences in sex at younger age. In fact, females tend to participate in team sports later than males, but rapidly dropped out. Even though this element, the participation in sport activities moves to gender equality in an adult environment (Lunn, 2010). This is confirmed by other studies that complement the approach by stating that the higher levels of dropout occur during adolescence, in girls, more than boys (Gould, 1987; Guillet, Sarrazin, Carpenter, Trouilloud, & Cury, 2002, Russell, Allen, & Wilson, 1996; Sallis & Patrick, 1996; Wankel & Mummery, 1996).

Secondly, overviewing the handball sports, as to incorporate the special circumstances of the sport in retention analysis.

Handball involves two teams in a common space that dispute the ball simultaneously, is a collective sport, of position and cooperation. It is known as a collective sport of cooperation-opposition (Hernández-Moreno, 1994), that have the same objective of making more goals than the opponent (Prudente, 2006). Prieto and Gómez (2012) also consider that is a contact sport with physical contact and some aggressiveness.

The dynamics of the game have evolved in terms of process, and therefore the need of knowledge about understanding the changes is relevant because it helps the definition of strategies (Sousa, Prudente, Sequeira, & Mendo, 2013).

Alongside with the specificity of Handball, that is characterized by modifying situations, as elements change in cooperation and opponents to overcome (Antón-García, 1998), the interaction between athletes comprises one of the factors that sustain the sport, and the evolution of it.

Also, participation in handball activities is organized with two-year age groupings that change throughout the development process. In this context, it might be also relevant the positioning of the triad coach-athletes-family and the communication process. Being a symbiotic relation that affects sports success (Pinheiro, Camerino, Costa, Baptista, Sequeira, 2017), the sport success is also dependent on the influence of the coach (Sequeira, Hanke, & Rodrigues, 2013, Todorov & Moreira, 2009, Williams & Kendal, 2007), as well as on the stability and growth of the players, the coach interaction and their influence in the retention. The coach's behavior impact on the athletes' motivation (Vallerand & Losier, 1999) and consequently in staying or dropping out.

Thirdly, it is central for strategy purposes to investigate how athletes behave along their growth in the sports. This cannot be separated from the need to be parsimonious if it aims to present relevant policy implications, turning this paper in a powerful tool for determining the main elements of the strategy.

In fact, physical activity policies consider the participation in sports and exercise activities as relevant in leisure-time physical activity. Understanding the phenomena, maintaining a high level of participation, and the knowledge of why some people practice and others not is of added-value (Lunn, 2010).

In the introductory section, we briefly describe the state of art of handball sports, overviewing the Portuguese context., which enables us to formulate the aim of the study. In the method section we provide the elements of the survival models, that have proven to be suited to the modelling and analysis of customer retention in different areas. Therefore, it might be applied to other areas, namely handball players. This analysis is made with the proviso that we are not aware of any research paper previously adopting survival models with sample selection in handball players. The discussion and presentation of results is done, followed by the conclusions.

Method

The survival analysis is process for data analysis for epidemiologic and other data. In our case, the variable is time until event occurs, determining the survival time of an individual over some follow-up time (Kleinbaum, & Klein, 2012). Therefore, measuring the time of handball players practice since the inscription in the federation until dropout was analyzed using survival analysis. The survival analysis was developed to understand the historical behavior of the dropout considering existing data in the sports federation. The survival analysis allows us to understand behavior of the dropout against the timings that occur using the concept of censoring (e.g. an athlete with an inscription two years before the observational period ends without a dropout), this allows to eliminate the bias of the non-survival analysis related to the discard of information of unobserved events (athletes without dropout) creating samples non-representative of the population studied.

Participants: The sample consisted of 133,717 handball players who were registered at least for one year (female $n = 47653$, mean age = 23.76, $SD=6.79$ years; and males $n = 86064$, mean age = 24.70, $SD=7.89$ years); data corresponded to the time period between August 1, 1997 and July 31, 2018, mainly with Portuguese nationality (99,96%). The main categories were Seniors (68,6%), U-18 (8,2%), Masters (8,1%), U-16 (4,8%), U-14 (4,2%) and other (6,1%) like: U-12, U-10, U-8 and U-6.

Procedure: This study was conducted in collaboration with Portuguese Federation of Handball in order to determine the level of players retention.

The variables were extracted from the management software of the federation correspond to the time interval of the athlete inscription until the end of observation (censoring on July 31, 2018) or the end of the athlete relationship (dropout). All athletes without an inscription before 2018 were considered that dropout. The survival time in the dataset is represented by the number of years an athlete remains registered. The data provided was been purged from element registered before 1997.

Statistical Analysis: Descriptive statistics were conducted to summarize the variables under analysis. The survival curve was measured to simplify the interpretation of the survival analysis. Data processing was conducted using Python (Continuum Analytics, 2016) and Pandas (McKinney & others, 2010). The Kaplan-Meier estimator was used to gather information about the dropout event and to estimate the survival (Efron, 1988), the log-rank was applied in the scale variables transformed to categorical using the quartiles to provide a statistical comparison

of groups and the categorical variable associations was analyzed considering the bigger associations and lower dimension where grouped to simplify the analysis. The survival analysis was conducted using the package *Lifelines* (Cameron Davidson-Pilon et al., 2017).

Results

This section contains the descriptive statistics and the instruments used in the study. A survival analysis was carried out with the purpose evaluating the retention of the players.

Descriptive statistics are displayed in Table 1, displaying an overall perspective of the analyzed data. The average age was 24.36 ± 7.53 years, and the average years before dropout was 2.98 ± 3 .

Table 1

Identification and description of the variables extracted

Variable	Description	Min	Max	Mean (SD)
Age	Age of the participants in years	0	85	24.36 (19.29)
Gender Category	Gender (0-female, 1-male) Masters, Seniors, U-18, U-16, U-14, U-12, U-10, U-8, U-6			
Country Associations	Portugal, Europe and others Porto, Lisbon, Aveiro, Viseu, Leiria, Madeira, Setubal, Braga, Algarve, Santarem and Others			
Dropout	Represents athlete dropout (0=active, 1=dropout)	0	1	0.89 (0.30)

Data regarding the survival time of the current sample during the first five years of practice is presented in Table 2. According to the results, the probability of the individuals continue sports participation for more than 12 months is 53%, with an estimated median survival of 22 months.

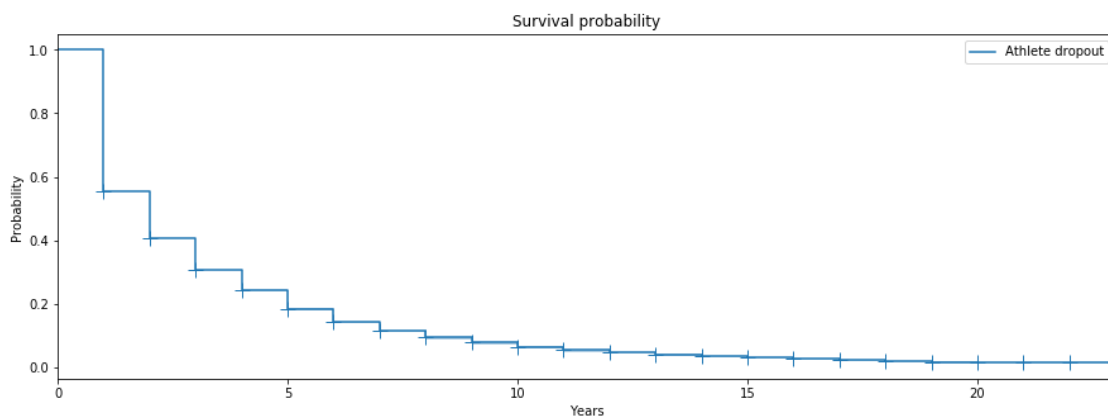
Table 2

Determination of the survival time probabilities of the athletes during the first five years of practice

Event Year	Removed	Dropout	Censored	Risk of Dropout	P _i	Estimated survival (years)
0	0	0	0	133717	1.00	2
1	60652	59395	1257	133717	0.55	3
2	21573	19482	2091	73065	0.40	3
3	14580	12904	1676	51492	0.30	3
4	8937	7576	1361	36912	0.24	3
5	8001	6820	1181	27975	0.18	4

Note: Removed – the sum of athletes with dropout and that are censored; Censored – the event did not occur during the interval of this data collection; Risk of Dropout – number customer in risk of dropout; p_i – survival probability; Estimated Survival - years to survive in the handball sport practice.

Figure 1 shows the Kaplan-Meier curve representing the estimated survival probability against the years. Each step down in the curve indicates the occurrence of one or more events (dropout or removed).

**Figure 1.** Survival probabilities

Using the logrank test, we identified significant differences between the groups in each variable: age ($\chi^2= 4185.70$, $p<0.01$), gender ($\chi^2=903.87$ $p<0.01$), category ($\chi^2= 10024.28$, $p<0.01$), and associations ($\chi^2= 1395.92$, $p<0.01$). There weren't significant differences in the variable country ($\chi^2=0.6$, $p>0.05$),

Conclusions

Reasons of Dropout in Handball are many. Results, Talent, Friends, Family, Coach, Competition and many others are referred as reasons for the Dropout of handball Players in different age stages. Our study wants to understand Dropout in Handball using existing historical data in the sports federation.. This can be through the estimated survival probability against the years.

According to our results, the probability of the individuals continue sports participation for more than 12 months is 53%. This means that is important to understand what happens in the first year of a Handball Player because it seems that 47% went out in this stage. On the other hand, it's important to research why Handball Players who play more years don't Dropout. We need to find relations between the survival probability and the Psychological and Social variables.

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E-HANDBALL: TECHNOLOGIE HELPS DEVELOPMENT

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Summary

Education plays a crucial role in the development of any Sport. Since the existence of the European Handball Federation, Education was always at the first stage of its mission. As in many others areas, also Education is evolving. With the new Technologies and it's tools it's now possible to teach in different ways that in the past did not exist. What EHF is doing in the present and thinking for the future is the purpose of this article.

Keywords: Handball, Development, Technology, Education

Introduction

Europe is very diverse, it has different languages, landscapes, cultures, tradition, etc. One thing that European have in common is the popularity of sport. Sport is a form of international communication, almost like its own language! This language is readily adopted and understood around Europe. Some sports travel well, across the whole continent but others don't (Parker, 2019).

Parker (2019) found in his study about sports popularity that Football is by far the most popular sport throughout Europe. It is the most popular sport in almost every nation that he analysed in the continent. Handball, Basketball, Ice Hockey, Volleyball and Skiing, after Football, are highly searched sports throughout Europe.

Today, Handball is a very intense and spectacular game! Athletes, Coaches, Referees, Delegates, Officials and Managers need to have the best performance to maintain Handball, in all it's variants (Indoor, Youth, Mini-handball, Beach Handball, Wheelchair Handball, ...).

Since the foundation of the European Handball Federation back in 1991, the development of Handball across Europe has been at the core of the federation's mission. Through the sharing and transfer of knowledge and expertise, material aid and financial support the EHF has sought to raise the standard of the game across the continent and to eliminate the handball 'blind spots' (EHF, 2013).

Absolutely essential in a knowledge-based economy is the role of education and training, and policy towards sport. Factors supporting growth and employment by encouraging the emergence of a highly qualified and adaptable population, they also strengthen social cohesion and active citizenship within the European Union. Through education and sport programmes, the European Union is developing and strengthening its dimension, promoting mobility and encouraging international cooperation (EUR-Lex, 2019).

Education plays a crucial role in the development of any Sport. Since the existence of the European Handball Federation, Education was always at the first stage of its mission. Its Member Federations represent and stand for different kinds of national and European handball know-how. Those individual national handball schools/philosophies shall be made use of by involving experts in order to contribute to the variety of handball education in Europe!

Handball know-how exchange and transfer in Europe shall be fostered as an EHF service for the EHF Member Federations by making use of national and international handball experts as well as external lecturers from sport science, medicine, other sports, economy (marketing, equipment suppliers) and media (press, TV, Internet). For this mission, EHF created the EHF Competence Academy & Network (EHF CAN): *“The EHF "CAN" shall be established as an educational service centre for EHF Member Federations with the possibility of granting scholarships in order to minimize or delete financial burdens for them. The same holds good for internal EHF Office management training on the job. The EHF "CAN" shall be established to develop and deliver sport specific educational and training programmes in order to ensure that coaches, officials, athletes and administrators from all over Europe (and the world) have access to the highest quality education relating to "handball know-how" and competence in e-learning, blended learning, interdisciplinary educational courses of various duration, summer schools or mainstream 2-4 semester courses within the European Education Credit Transfer System (ECTS framework). The EHF "CAN" shall set-up Business Executive Education programmes for further educating and training sporting administrators, resort managers and event executives in the Handball Event Management Business, e.g. also in event-related courses. The EHF "CAN" shall contain a documentation centre including production of modern teaching aids and media as well as cooperation agreements with research & developing partners, suppliers, universities and testifying institutions.”* (EHF CAN, 2019).

With the new Technologies and it's tools it's now possible to teach in different ways that in the past did not exist. For example, today all the Courses organized by the EHF (and also the National Federations) for Coaches, Referees, Delegates or Managers use Videos in its contents and presentations. The “Visual Education Process” proved to have enormous success in the last years.

The EHF has a very good platform with documents, videos and other materials.

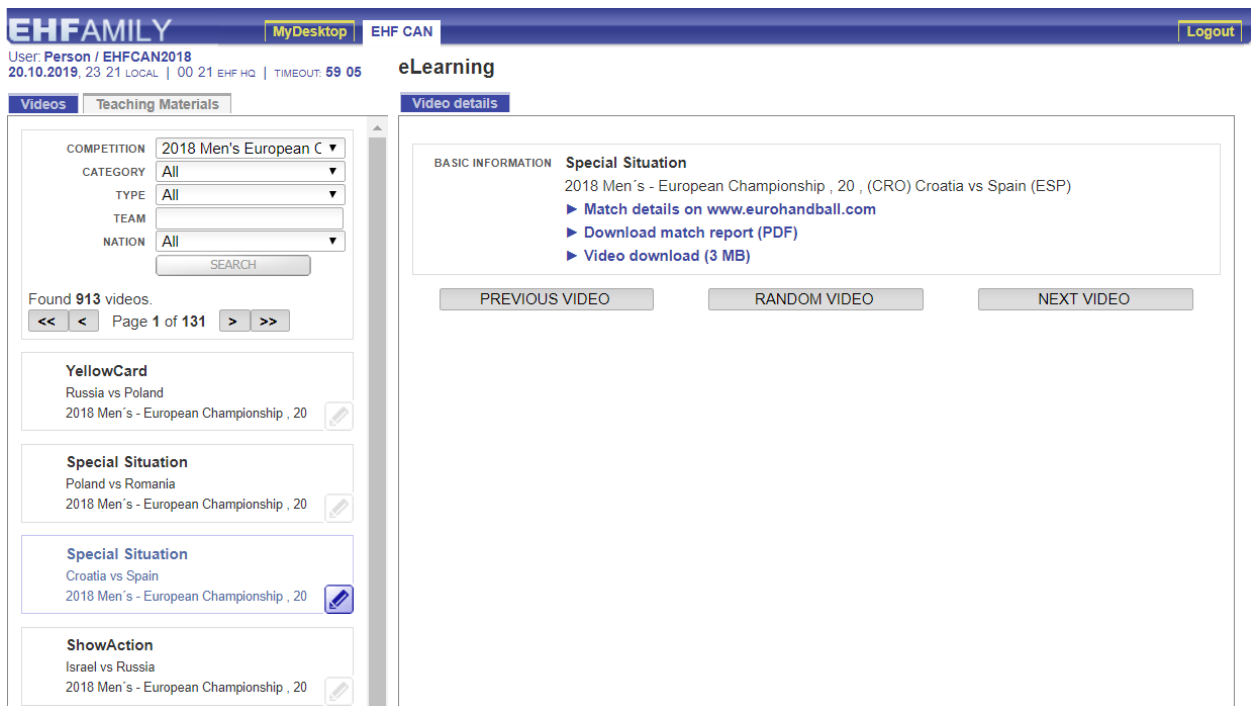


Figure 1 – EHF e-learning Platform

Now this is used through a new methodology and pedagogical process, named e-learning. According to the Cambridge Dictionary, *e-learning is the learning done by studying at home using computers and courses provided on the internet*. Being asynchronous, the graduates have access when they want, the tutor/lecturer teaches through forums, messages, documents and many other tools that the e-learning platform provides. If it's synchronous, then the tutor/lecturer and the students have hours where they are simultaneous online and interact during the education process, using the tools referred before.



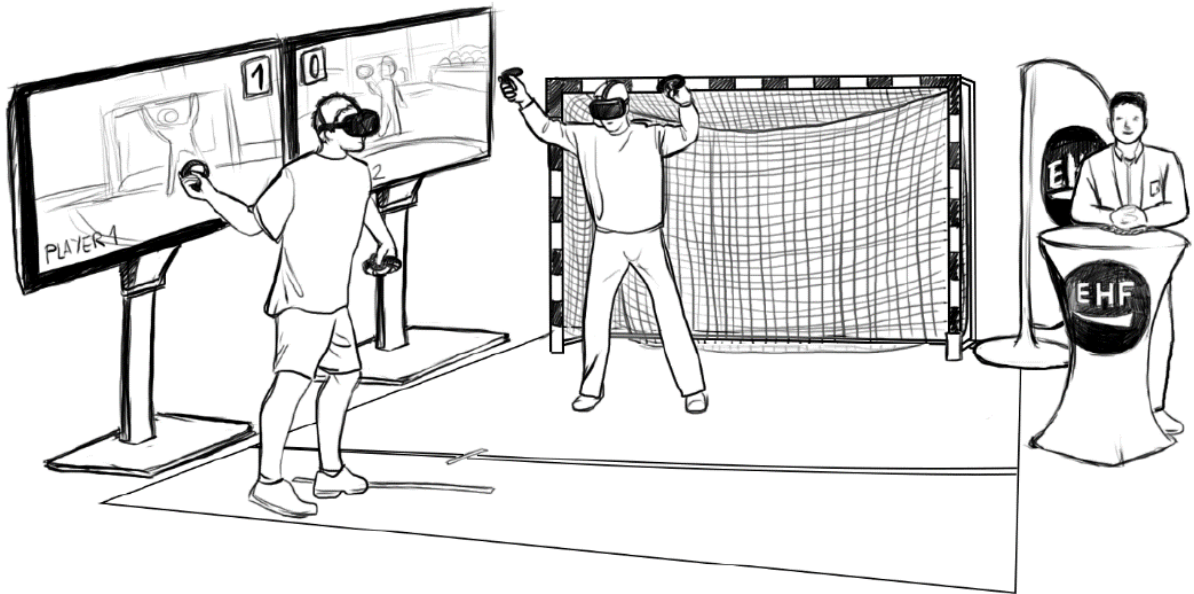


Figure 2 – Handball Virtual Environment

But new challenges are coming. Virtual Reality (VR) glasses will be used to play “virtual” Handball. This will give a large range of opportunities to help to develop Handball (Entertainment, Training, Education, etc.). Focusing in Education, VR glasses will help Coaches “to see” as their players see and then correct them. But also to teach Coaches to “see better” everything that happens during practices and games.

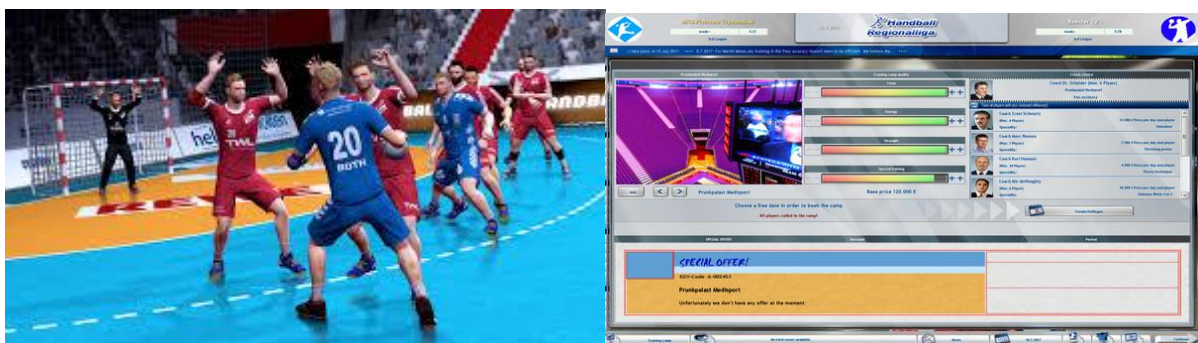


Figure 3 – a) IHF Handball Challenge 17 and b) Handball Manager Team

Also e-sports is a future challenge to Handball. Not only to promote the game and players (FIFA 2019 and Football Manager 2019 are very good examples) but also as an education tool because they will help Coaches and Referees to understand better all the components of the game!

Final considerations

Technology is developing in many directions. Today, we have a lot of technology tools at our disposal that can help us to develop Handball in the direction we want. We think that definitely education is one area where Handball will continue to use technology. E-learning and Virtual Environments (present and future) will continue to be developed (e-learning is already in use in the last years, VR is starting since 2019) to help the education programmes of Coaches, Referees and Delegates. But technology will also continue to be very useful to help Coaches during training sessions and games. For every new need, companies will invent new tools, software's and materials to improve Handball Players performances. We also believe that Handball as an e-sport will help to promote all the sports agents (players, coaches, officials, referees) but Handball itself. Through this new environment Handball can reach Countries and places that with "real" Handball would take more time.

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E-SPORTS: HANDBALL NEW CHALLENGE

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Summary

In this article we show evidence that e-sport is a growing fast market, in Europe and in the World, that can contribute for the Handball development, fan engagement and revenue.

Thus, we propose the existence of a quality handball game, based on new technology, in order also to help handball sports agent's education.

Keywords: E-sports, Handball Development, Fan Engagement, Coach Education

Introduction

E-sports, or electronic sports, are organized video game competitions (Jenny, Manning, Keiper, & Olrich, 2016) on interconnection of multiple platforms. E-sports is computing, gaming, media, and a sports event all wrapped up into one (Jin, 2010).

E-sports has gained immense popularity in youth cultures around the world since the inception of online gaming in the early 1990s (Wagner, 2007). It is very popular for several reasons, namely for allowing fans to follow their favourite tournaments and online players (you can follow your favourite player's talk throughout the game), and because it is easier for amateurs to participate in e-sports (Heaven, 2014). Some of the first organizations that made e-sports popular are from Europe (ESL, the world's largest e-sports organization) (NewZoo, 2017). The recent popularity of competitive e-sports has spawned from all over the world as many countries have television channels dedicated to e-sports (Wingfield, 2014), and different levels and types of competition.

It has become a world-wide sensation in a way that e-sports-specific venues are increasingly being built while other constructed primarily for other professional sports or entertainment, are hosting e-sports competitions all around the world, particularly in the USA, Europe, and Asia (Jenny et al, 2018).

Millions of fans attend professional e-sports competitions in varying venues (Keiper, Manning, Jenny, Olrich, & Croft, 2017). These events involve e-sports players arranged in a stage in front of desktop computer stations where the action is broadcast live via Jumbotron, within the venue (Jenny et al, 2018).

In 2014, more than 205 million people globally watched or participated in e-sports (Casselmann, 2015). Global e-sports awareness has reached 1.3 billion people (more 15% than 2016), including 191 million e-sports “enthusiasts” and 194 million “occasional viewers” (NewZoo, 2017). Nowadays, e-sports events can easily fill arenas while the prize money can rival or even exceed what is offered in many traditional sports. In 2016, 424 worldwide e-sports events were held with prize purses greater than €5,000, where combined prize were over €93 million—more 50% than 2015 (NewZoo, 2017).

Unlike many existing pro sports, the e-sports audience is young, digital, and global: 79% of viewers are under 35 years old, men (71%) and women (29%) and more than 50% are in Asia. Online video sites like Twitch and YouTube have a larger audience for gaming alone than HBO, Netflix and ESPN combined (GoldmanSachs, 2018).

The market

E-sports market is defined as the accumulated revenues of e-sports leagues and events, as well as team organisations. E-sports attract more than €500 million in sponsorships annually, such as Coca-Cola, Red Bull, Intel, and Nissan (Casselmann, 2015).

Asia and USA

Asia is leading the way for e-sports, globally. As of 2017, China accounts for 26 percent of global game revenue and active game users. China’s e-sports market is built upon the largest gamer base in the world, with approximately 442 million gamers in 2017, according to CNNIC (GoldmanSachs, 2018). There are 575 million digital game consumers in China as of 2017. China’s game market has grown quickly: from 2013 to 2017 the value of China’s market has more than doubled from more than €13.8 billion to € 2.5 billion. While United States game market reached around €25 billion in 2017 with fewer than 180 million customers. Furthermore, beyond collegiate club sports, 42 USA colleges and universities are members of the National Association of Collegiate e-sports (Jenny, et al, 2016), which recognize “varsity” e-sports teams. Colleges and universities are rapidly beginning to launch e-sports programs within their athletics departments. Five colleges offered e-sports scholarships for the 2015-2016 academic year (Kelly, 2015).

Europe

Europe has been one of the most important regions in the development of the e-sports industry and is a very different region from other large markets such as North America or China, as it represents more countries and cultures than that two regions (NewZoo, 2017). The European e-sports market has seen strong average annual growth of about 24% since 2016, with total revenues amounting to €240 million in 2018 (Deloitte, 2019), thus attracting more stakeholders every year.

E-sports stadium attendance has seen substantial growth over the last few years (e.g.: 173,000 people attended a tournament in Poland in 2016, more 113,000 than 2015 (Elder, 2017 cit in Jenny et al, 2018). In 2015, seven venues had crowds over 13,000 for a single e-sports event, with five having over 20,000 (Kresse, 2016b, cit in Jenny et al, 2018). In 2018, the European e-sports audience was about 86 million people an increase of 28% (19 million) over 2016. It is expected in the next year 105 million people to be watching e-sports in Europe by 2020.

EUROPEAN ESPORTS AUDIENCE

EUROPE | FOR 2015, 2016, 2017, 2020 | Q3 2017

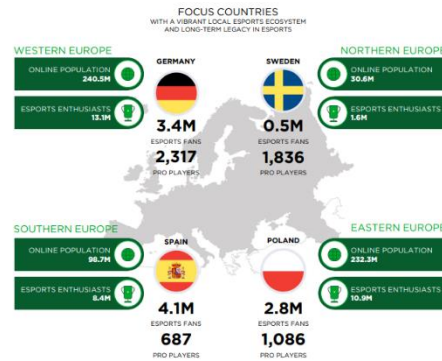
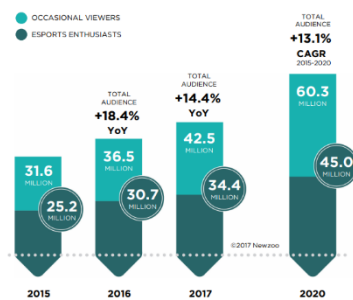


Figure 4 -a) European e-sports audience and b) Focus Countries

Traditional sports clubs are becoming increasingly involved in the e-sports market (e.g. Barcelona, PSG, AS Roma, Manchester City, Schalke 04). These sports clubs are often well-known brands with a huge fan base and their involvement in e-sports that could potentially lead to fast development of the European and global markets.

Though many soccer clubs are attempting into e-sports, teams from other sports, such as basketball, American football, baseball and racing, are also becoming involved. A recent study in the USA found that 52% of e-sports fans were also fans of NFL teams, while 39% were NBA and Major League Baseball fans (NewZoo, 2017).

As league infrastructure develops for more games, it is expected to see a step function change in monetization for e-sports. In 2017, it was estimated that e-sports generated €655mn in annual revenue, including 38% from sponsorships, 14% from media rights, and 9% from ticket revenue. Deloitte (2019) estimated there was around €3.9bn investment in the sector worldwide. By 2022, it is expected that figure will reach €2.96bn and media rights to reach 40% of total e-sports revenue. In Europe, revenues are expected to grow 23% per year to reach €670m by 2023.

Whereas sponsorships make up the largest percentage of global revenue today, it is predicted that media rights will eventually become the largest source of e-sports revenue, as massive audiences and associated ad revenue for established online video platforms (Twitch, YouTube, Douyu, and Huya) will be able to support a growing pool of media rights to top publishers.

Current studies demonstrate that traditional sport and e-sports are similarly consumed, suggesting that sport industry professionals can manage and market e-sport events similarly to traditional sport events (Pizzo, et al, 2018). Recently, Epic hosted a Fortnite Celebrity Pro-Am Tournament at E3, featuring 50 teams of two (one Pro, one Amateur celebrity per team) competing for a €3 million dollar charity prize pool. The 3-hour long event included popular game streamers, athletes, musical artists, and actors. At its peak, the tournament attracted 700,000 concurrent viewers on Twitch.

E-sports is entering a new phase toward becoming a mature market (NewZoo, 2017) and is a rapidly emerging success story across Europe (Deloitte, 2019).

The key factors are the success of local leagues and the franchising approach, the implementation of regulations, the arrival of new game formats and competition, the uptake of content rights sales, team profitability, and the impact of industry convergence involving traditional media, entertainment, telecom, and sports companies (SuperData, 2017).

Challenges and opportunities for the Handball family

Following the context previously described we can foresee opportunities for the Handball family. But in order to be successful some challenges need to be overcome.

European market is growing and expected to continue to grow. It is well development as reported in countries where handball is part of the “traditional” teams’ sports (e.g.: Germany, Sweden, France, Spain). And this can also be a global opportunity as well to development and take the handball brand to countries where is not so popular (or unknown), like Commonwealth of Nations and USA.

The first, and if not, the biggest challenge it is to produce a Handball game that capture the e-players and handball fans. Handball is a sport that has had its game simulators both real and fantasy, but not as successful as other sports (PES, FIFA). One might say that mainly due to lack/poor of gameplay related to human computer interaction issues. Below we present the most popular games related to our sport.

IHF Handball Challenge 17 features entirely redesigned gameplay revamped artificial intelligence and new levels of difficulty for an experience that is as close as it gets to the real thing while still being easy to play. The game gives access to 82 official teams from the most prestigious European leagues: the LIDL Star Ligue and Pro D2 in France, the DKB Handball Bundesliga & 2. Bundesliga in Germany and the Liga ASOBAL in Spain (Bigben, 2019).

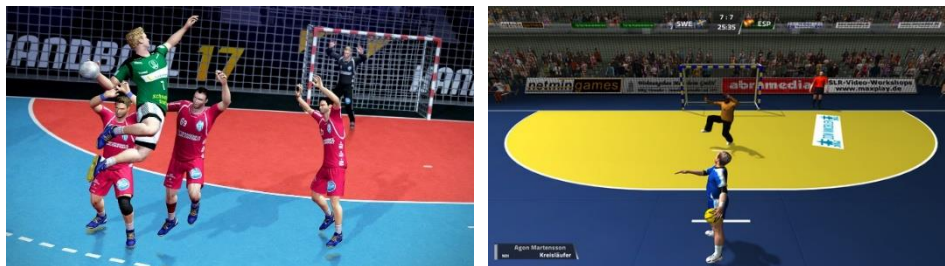


Figure 2 – a) IHF Handball Challenge 17 and b) Handball Action Total

Handball Action Total is a 3D Handball Experience with realistic game play. You can choose between many national and international teams or create your own competition and take part in all of the world's most important tournaments or make your own tournament (Netmin, 2018).

Steel Circus is the Handball match between the Robotic Clown. Basically, Steel Circus throws you and other players into a closed arena, playing handball. But it's not our time's handball matches. It's a handball match in advanced technology with MOBA elements (Interactive, 2019).

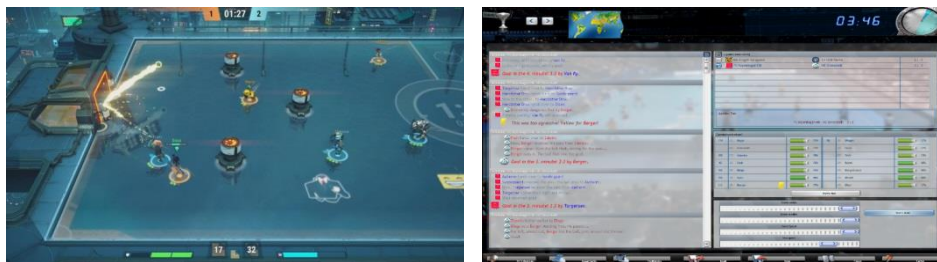


Figure 3 - a) Steel Circus and b) Handball Manager Team

Handball Manager Team - Manage your favorite club. The line-up of the team belongs to the player. The know-how and feeling decides about win or loss. Sending team out for trainings camps or increase the bonus and motivate the teams for unbelievable performances. Maintain and enlarge the hall, negotiate with advertising partners and if everything runs smoothly enjoy the international fame. Based on the well-known (and critically acclaimed) titles from Greencode / Heartline (known since more than 20 years for great Sports Management Games) (UniqueGames, 2017).

Nowadays, PC is still the primary platform for e-sports worldwide. The top 10 e-sports titles (measured by prize money) are primarily or exclusively PC-based titles, where in China, 56% of total games revenue in 2016 came from that source (NewZoo, 2017). And 7 of (top 15 e-sports in-game purchases) highest monetizing PC and console games are also the same games that has the most total prize money paid out to players.

The game itself could be multiple platform that could be used as a game but also as an education and/or training tool, when complemented or built with adequate technology (Augmented reality sets, virtual reality headsets, haptics suits...). The handball game would be a match and/or training simulator and it could be used to help to improve performance regarding the better understanding of the perception-action loop used by the players. It had to be an interactive, immersive virtual reality environment to overcome the limitations of depth and foster a better understanding of the handball game by allowing the players, coaches, referees and fans to “feel” different points of view. In three-dimensional virtual and in augmented realities, people can interact with each other and with virtual elements.

Regarding coaching education, a game with these features would fulfil all different levels of technical and tactical requirements as it allows to document the scripting of the movements and interactions automated by bots or online with any user or fan. Users could communicate while playing or watching the game together within different points of view. Our proposed system aims to improve the quality of the educational content by allowing sports agents or fans to visualize tactics in three-dimensions in a shared environment, where they can analyse them from different perspectives and cooperate by demonstrating changes to the stored tactics using their own avatars alongside automated bots (Lopes, et al, 2009).

The second challenge is the acceptance of the e-sports as a part of the Handball family and involvement of this later one for its institutionalization by promoting e-sports activities: stand alone, regular competitions and exhibitions or blended in Handball main events. These types of events will help to promote and capture new fans, players and stakeholders for e-sports but for Handball family as well. In this ways e-sports can help to increase the audience of games (venues, TV broadcast and online) and player and fan engagement. It is important to understand the implications of culture on favourite games, teams, and players. The involvement of sports clubs and personalities will contribute to the e-sport development. The inclusion of well-known sports teams gives a boost to the awareness and acceptance of e-sports as a form of conventional entertainment.

Final considerations

We propose an investment in good Handball Video Games, as e-sports is becoming a mature market and is a success story across Europe and globally. Traditional sports clubs and leagues could help and benefit from the e-sports, as they have an established local fan base, along with a well-known and respected brand that can allow access to a new potential source of revenue. Although younger generations communicate via online, and social interactions take place online, we consider e-sports as an interactive and social form of sports related to traditional sports, and have confidence in that this would have a positive impact in promoting the game (particularly in places where handball is less known), as well as in coaches, players or referee's education. Will handball family stay "in passive game"?

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THE REFEREE'S AGE AND EXPERIENCE VERSUS THE ACCURACY OF HANDBALL REFEREE DECISIONS AT VARIOUS LEVELS OF COMPETITION

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Summary

The aim of the study is to examine the level of rightness referee's decisions in handball and also to determinate relations between the quality of decisions making and age as well as work experience. The main method used to assess the quality and quantity referee's decisions is categorized observation of 72 handball matches based on the research tool such as a decisions registration sheet. The referee's assessment was based on 10193 decisions and the study involved 72 referees. The results indicated that referee's made more mistakes at lower standard of competition. It was found that there is a relation between age & experience and the number of wrong and correct decisions as well as total lack of response to the violation of the rules of the game.

Keywords: decisions making, refereeing, team handball, handball referee, age

Introduction

Unquestionable influence on the understanding of the rules of handball has referees, because on their professionalism, good attitude and transparency of actions in accordance with the current rules of the game depends a lot. In the field of scientific exploration, well defined in the area of refereeing in team sports games, it is possible to find groups of topics scrupulously analyzed by scientists.

However, many studies indicate the movement of the referee on the field (Adnan, Muzayin, Sulaiman 2013; Castagna, Abt, D'ottavio 2004; D'ottavio, Castagna 2001) and related modification of physiological indicators (Borin, Daniel, Bonganha, Moraes, Cavaglieri, Mercadante, da Silva, Montagner 2013; Kraak, Malan, van den Berg 2011; Mallo Sainz, Navarro Cabello, Garcia Aranda, Helsen 2009; Barbero – Alvarez, Soto, Barbero – Alvarez V., Granda – Vera 2008; da Silva, Fernandes, Fernandez 2008; de Oliveira, Guerrero Santana, de Barros Neto 2008; Reilly, Gregson 2006), in proportion to the amount of liquids consumed by referees (Da Silva, Fernandes, Fernandez 2011, 2008), the noticeable majority of articles concern the training and physical preparation of referees (Weston, Batterham, Castagna, Portas, Barnes, Harley, Lovell 2011; da Silva, Castagna, Carminatti, Foza, Guglielmo, Oliveira 2010; Bartha, Petridis, Hamar, Puhl, Castagna 2009; Erčulj 2009; Mrković, Talović, Jeleškovic, Alić, Bajramović 2009; Weston, Castagna, Helsen, Impellizzeri 2009; Casajus, Castagna 2007; Weston, Castagna, Impellizzeri, Rampinini, Abt 2007; Castagna, Abt, D'ottavio 2002; Castagna, D'ottavio 2001; Krustup, Bangsbo 2001). Simultaneously, there is an increase of interest in the issue of refereeing by psychologists, who characterize the psychological features and personality of the referees (Schwartz, Carl 2014; Johansen, Haugen 2013), as well as stress (Wolfson, Neave 2007) and expose the bias of referees (Lopez, Snyder 2013). Incidentally, the assessment of the work of basketball (Słupczyński, Dulnik, Filipowicz 2008; MacMahon, Starkes, Deakin 2007) or rugby (Mascarenhas, Collins, Mortimer 2005) referees has been performed.

The result of a sporting event depends not only on the current condition of the players, but also on the current physical and mental condition of the referee. Adequate physical preparation helps to "keep up with the action" and assess action in a consistent way with game rules. The assessment made by the subject is related to the distance from the object of description (Szmajke 2001; Aronson, Wilson, Akert 1997; Trzebiński 1985). As it has been indicated by Castagna and D'ottavio (2001), a higher level of VO₂max allows the referees to conduct the match more actively, moving closer to the action. A lower ability to maintain high intensity physical activity during the second half of the match leads to a fatigue accumulation (Weston, Castagna, Impellizzeri, Rampinini, Abt 2007; Krustrup, Bangsbo 2001) and can influence referees' decisions. In addition, a reduction in physical fitness during the initial phase of the second half of the match was found in football referees compared to the corresponding phase of the first half of the match (Weston, Batterham, Castagna, Portas, Barnes, Harley, Lovell 2011).

The appreciation of the referee's age is related to the decrease of oxygen efficiency (Erčulj 2009) as well as anaerobic efficiency (Casajus, Castagna 2007). On the other hand, the older referees are able to reach a level of physical fitness that is appropriate to handle the requirements of a match at the highest level of competition (Casajus, Castagna 2007). This is extremely important, as sports referees reach the peak of their sporting career by usually being middle-aged (Castagna, Abt, D'ottavio, Weston 2005). In addition, Castagna, Abt and D'ottavio (2002) point out that the 12-minute run test is extremely important in the evaluation of the physical preparation of a football referee, as well as sprints on 50 and 200 metres, which should be carried out both at the beginning, in the middle and after the end of the season. Fitness requirements and norms should be established taking into account the age criterion of the referee (Castagna, Abt, D'ottavio, Weston 2005), since there is a risk that young referees who achieve minimum results but enable them to pass the fitness test - in middle age - will have real problems with proper preparation for the season.

Decisions made by the referees have become an increasingly numerous subject of scientific analysis over the last decade, but the accuracy of decisions made by referees is an undefined issue in scientific research, which is a significant gap in knowledge described in this study.

The aim of this study was to determine the level of accuracy of decisions made by handball referees of different levels of formal competence and their relationship with the age and experience of referees.

Methods

The persons who have been tested in this study are handball referees who, on the basis of the results of annual theoretical tests on knowledge of the game rules, fitness tests and the assessment of delegates nominated by the Committee of Referees, were qualified to conduct competitions at three levels of the competition, namely: Superleague, I league and II league. For the purposes of the study - out of the entire population of referees qualified to conduct competitions (n=144) – a random selection was made consisting 50% of the population at each of the three levels of the competition, i.e. 22 referees at the Superleague level (11 pairs), 34 referees at the I league level (17 pairs) and 16 referees at the II league level (8 pairs). The analysis included 72 matches (24 matches each at each level).

Table 1: Characteristics of the tested persons.

	1. Superleague referees	2. I league referees	3. II league referees
Age	35.2 ± 5.2	32.8 ± 6.6	26.7 ± 6.6
Seniority (years)	13.8 ± 4.4	10.9 ± 5.1	6.4 ± 4.4

The research material consists of numerical data obtained by registering 10193 decisions made by league referees during the 2012/2013 and 2013/2014 seasons.

The method used in this study is a categorized observation of digital recording of league matches made on the basis of a research tool, in the form of a worksheet for registering decisions of referees according to the concept of Słupczyński (2008) with the author's modification. This worksheet, developed in accordance with the recommendations of the Committee of Referees of the Polish Handball Association, enables the assignment of each match situation to the content of specific paragraphs of the game rules. Modified author's observation worksheet contains a catalogue of 132 match situations, which were evaluated as: right decisions, wrong decisions, lack of reaction to violations of game rules. This article presents several selected issues from the group of 132 situations, possible to occur during handball games.

The statistical method used in this study to analyze qualitative data was the non-parametric Kruskal-Wallis test, which determined the level of significance of differences between numerical values describing the quality of arbitrators' decisions of different levels of competence. To identify the most important factors - variables influencing the quality of decisions made by referees, the Spearman's rank correlation was applied. All calculations and analyses were performed using STATISTICA software (v.9.1, Stat. Soft. USA).

Results

Analysis of all decisions made by the referees according to the level of formal competence.

Table 2: Overview of the number of types of decisions made by the groups of referees (general aspect).

	A	B	C	Σ
Σ	6099	820	3274	10193
M	84.7	11.4	45.5	141.6
SD ±	9.6	8.6	17.8	22.2

Legend:

Types of decisions: A – right decision, B – wrong decision, C – no reaction

Analysing the total number of different types of decisions made by all referees on the basis of the data presented in the table above, it was found that an average of 141.6 decisions per match were made in 72 matches.

The evaluation of the quality of the decisions made showed that 59.8% were right decisions (M=84.7), 8% (X=11.4) - wrong decisions, and 32.2% (X=45.5) were concerned with situations where referees did not react to a violation of the rules of the game.

Table 3: Diversification in the number of decisions made by the groups of referees.

	1. Superleague referees (n = 24)	2. I league referees (n = 24)	3. II league referees (n = 24)
Σ	2931	3341	3921
M	122.1 *** (3) *(2)	139.2 ** (3) *(1)	163.4 *** (1) ** (2)
SD \pm	7.0	18.5	15.5

Legend:

n - number of analyzed matches

1, 2, 3 - the groups of referees

Materiality level of differences – * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Considering the numerical values describing the average number of all decisions made by referees with different levels of formal competence, on the basis of the data presented in the table above, it was found that the most decisions in a match were made by referees of the second division (M=163.4), then by the referees of the first division (M=139.2) and the least referees presenting the highest level of formal competence, the Superleague referees (M=122.1).

Analysing the degree of diversification of the total number of decisions of the compared groups of referees on the basis of the results of the Kruskal-Wallis test, it was found that the referees of the second division made significantly more decisions than the other groups of referees. In addition, the Superleague referees made significantly less decisions than the referees in the first and second league competitions.

Table 4: Diversification in the number of types of referees decisions (general aspect)

	1. Superleague referees (n = 24)			2. I league referees (n = 24)			3. II league referees (n = 24)		
	A	B	C	A	B	C	A	B	C
Σ	2156	68	707	2111	224	1006	1832	528	1561
M	89.8 *** (3)	2.8 *** (2,3)	29.5 *** (3) ** (2)	88.0 *** (3)	9.3 *** (1,3)	41.9 *** (3) ** (1)	76.3 *** (1,2)	22.0 *** (1,2)	65.0 *** (1,2)
SD \pm	7.6	2.1	4.9	9.2	2.5	12.8	5.6	4.5	10.3

Legend:

n - number of analyzed matches

1, 2, 3 - the groups of referees

Types of decisions: A – right decision, B – wrong decision, C – no reaction

Materiality level of differences – * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Analysing the level of differentiation of values describing the number of particular types of decisions in the analysed groups of referees, on the basis of data presented in the following table 4 and the results of the Kruskal-Wallis test showed that the average number of right decisions made by Superleague (M=89.8) and I League (M=88.0) referees was significantly higher than the value characterizing the right decisions of II League referees (M=76.3).

With regard to the data showing the level of variation in the number of wrong decisions, it was found that the Superleague referees (M=2.8) made significantly less such decisions than the referees of the I league (M=9.3) and II league (M=22.0). Moreover, the referees of the I league made significantly less statistically wrong decisions than the referees of the II league.

Considering the differences in the values concerning the number of situations in which the referees did not react despite the violation of the game rules, it was found that the Superleague referees (M=29.5) had significantly less lack of reaction than the first league referees (M=41.9) and second league referees (M=65.0). In addition, the referees of the I league differed significantly from the referees of the II league in this regard.

Analysis of the correlation relations between the accuracy of decisions and the age and seniority of referees.

Table 5: Summary of Spearman's rank factors showing the type of correlation between quantitative features and the level of differentiation in the types of decisions of referees.

Pair of variables	N ważnych	R_s
Age & number of all right decisions	61	0.342 **
Age & number of all wrong decisions	61	-0.450 ***
Age & number of total non-response reactions	61	-0.394 **
Referees seniority & number of all right decisions	60	0.340 **
Referees seniority & number of all wrong decisions	60	-0.620 ***
Referees seniority & number of total non-response rates	60	-0.550 ***

Legend:

R_s – Spearman's rank factor value

Materiality level of differences – * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Analyzing the values of Spearman's rank coefficients, reflecting the strength and direction of the relationship between quantitative features and the level of differentiation of the types of decisions of referees - according to J. Guilford's classification (Wróblewska 1990) - it was found that:

- there is a significant, average positive correlation between the age of the referee and the number of all the right decisions made by the referee during the match;
- there is a significant, average negative correlation between the age of the referee and the number of all wrong decisions made by the referee during the match;

- there is a significant, average negative correlation between the age of the referee and the total number of lack of reactions given by the referee during the competition;
- there is a significant, average positive correlation between the referee's seniority and the number of all the right decisions made by the referee during the match;
- there is a significant, high negative correlation between the referee's seniority and the number of all wrong decisions made by the referee during the match;
- there is a significant, high negative correlation between the referee's seniority and the total number of lack of reactions given by the referee during the competition.

Discussion

Analysing the results of the research included in this study, reflecting at the outset on the accuracy of all the decisions of all the tested referees, one may become aware of the concerns, as the results of the research show that only 60% of all decisions were right (32% - lack of reaction to the existing violation of game rules, 8% - wrong decisions). However, it is worth noting a number of factors and variables associated with this issue.

First of all, referees carrying out competitions at a lower level make more decisions during the match than referees of higher classes. This is confirmed by the above analyses, which show that the referees of the second division made more than 25% more decisions in the match ($M=163.4$) than the Superleague referees ($M=122.1$). It should be noted that the referees of the second division made significantly more decisions than the other groups of referees. The observed regularity that a higher level of league matches determines a lower number of decisions made by referees in general is confirmed by the Słupczyński study (2012), which shows that in basketball the applicants referee made significantly more decisions than other groups of referees. Mascarenhas et al. (2006) concretised similar conclusions, according to which effective refereeing of football matches is characterised by a lower number of referees' interventions.

Secondly, the relevance of decisions made by referees with different levels of formal competence varies significantly. At the Superleague level, 73.6% of decisions are correct, while first league officials make only 63.2% and second league officials only 46.7%. These results could be a sign of inexperience and dilemmasia in the work of referees, however, one should pay attention to the specificity of the decision registration worksheet used and the level of detail. While trying to defend the referees with the highest level of formal competence, the results of the research were referred to, presenting the values that characterise wrong decisions; in the case of Superleague referees, it is only 2.3% of all decisions made - in comparison to first league referees (6.3%) and second league referees (13.5%), where the number of mistakes is several times greater. However, the fact that 24.1% of all decisions made by the Superleague referees constitute a lack of reaction to a violation of the game rules, regardless of the details of the analysed data, may indicate a certain difficulty in evaluating some match situations. The proportions of lack of reaction in the case of referees of I and II league are higher, i.e. 30.1% and 39.8% respectively.

Monitoring the values of Spearman's rank coefficients, reflecting the force and the direction of the relationship between the referee's seniority (experience) and the number of all wrong decisions made by handball referees, a statistically significant, high negative correlation ($R_s = -0.620$, $p < 0.001$) can be observed. A similar, high negative correlation was also observed between the referee's seniority and the total number of lack of reactions to violations of game rules committed by referees during sport competition ($R_s = -0.550$, $p < 0.001$). Therefore, it can be concluded with all conviction that refereeing seniority plays a significant role in making the right decisions during the match, which is additionally confirmed by the statistically significant positive correlation between seniority and the right decisions of the referee ($R_s = 0.340$, $p < 0.01$). Similar conclusions were reached by Słupczyński (2012), who proved that there is

a statistically significant correlation indicating a strong positive relationship between referee seniority and the proportion of good decisions made by referees in a basketball match. However, in all analysed groups of referees with different levels of formal competence, both young referees - twenty-years-old and older referees - thirty- and forty-years-old (Superleague referees' age - M=35.2; I league - M=32.8; II league - M=26.7), a statistically significant, average negative correlation between the age of a referee and the number of all wrong decisions ($R_s = -0.450$, $p < 0.001$) and lack of reaction of the referee during a sport competition ($R_s = -0.394$, $p < 0.01$) can be observed.

Despite the fact that the appreciation of the referee's age is associated with a reduction in oxygen and anaerobic capacity (Erčulj 2009; Casajus, Castagna 2007), senior referees are able to reach a level of physical condition that adequately suits the requirements of the match at the highest level of competition (Casajus, Castagna 2007). This is extremely important because, according to Castagna, Abt, D'ottavio, Weston (2005), referees tend to reach the peak of their career when they are generally middle-aged, which, as confirmed by these studies is associated with their better performance on the sports field.

This study shows that it is the rightness of the decisions made by the referees that should be the most important aspect, because at the highest level of competition any wrong decision of the referees may decide about victory, defeat and at times about the championship.

Conclusions

1. The results of the analysis of empirical data presented in this article have expanded the existing knowledge in the research area by characterizing the structure of the quality of decisions made by judges with different levels of formal competence.
2. The conducted research, interpretation and evaluation of the results do not exhaust the whole issue of the quality of the referee's work on the sports field, therefore - it is advisable to continue and expand the range of scientific considerations in this area - in order to search for new factors influencing the proper work of the referee.

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PECULIARITIES OF MOTIVATION IN THE ACTIVITY OF PROFESSIONAL HANDBALL PLAYERS

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Summary

In this article were given results of researches of motivational sphere of the personality of professional handball players. On the basis of the conducted researches, the authors analyzes the results and draws conclusions.

Keywords: motivation, motivation of sports achievements, sport of higher achievements.

Introduction

The motivation of sport achievements is one of the most important and positively influencing factors in sports activities of professional handball players, the preservation of effective game activity during the whole career of the player depends on motivation. Psychological maturity and readiness of the player for his sports achievements are also of great importance, as well as the natural and continuous striving to improve the achievements. This is the aspect, in which the motivation of sports achievements has been one of the most important and acute problems of sport of the highest achievements both in theoretical-methodological and practical plane.

Methods

The subjects of the research were 23 adult and professional handball players. The experimental group (EG) consisted of 16 handball players with high qualification. The control group (CG) consisted of 7 handball players who were of reserve handball players. In our research we have used the tests, developed by D.A. Leontyev (Methodology of life-purpose orientations), H. Eysenk (Methodology for temperament determination), T. Ehlers (Methodology for diagnostics of a personality for the motivation to succeed, Methodology for diagnostics of a personality for motivation to avoid failures).

Results

Our research was conducted to establish the interrelation between social and personal factors of play activity of handball players and based on it to determine the most efficient means and methods of forming the sports achievements motivation.

The methodology of life-purpose orientations (LPO) was used to identify the system of values of the professional handball players. The data in Figure 1 show that the highest priority for the experimental group (EG) is: health (81.3%) and wealth (75%).

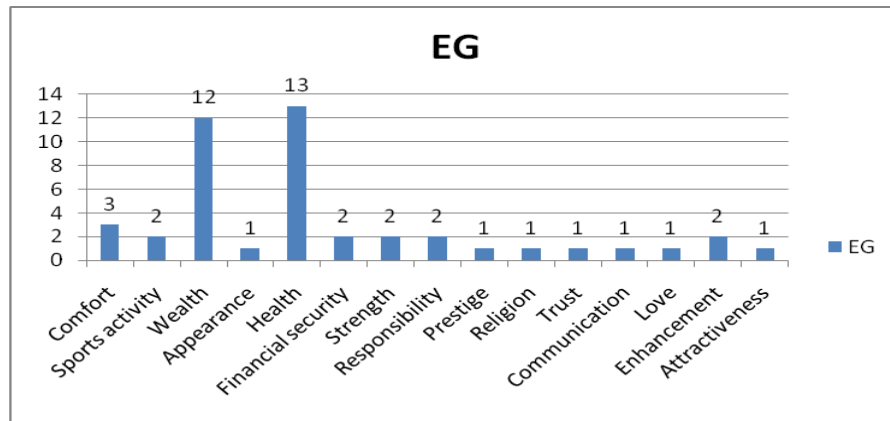


Figure 1 - The highest priority for the experimental group (EG)

The study of the same parameters in the control group (CG) has shown that their priorities are: life comfort (57.1%) and wealth (57.1%), Figure 2:

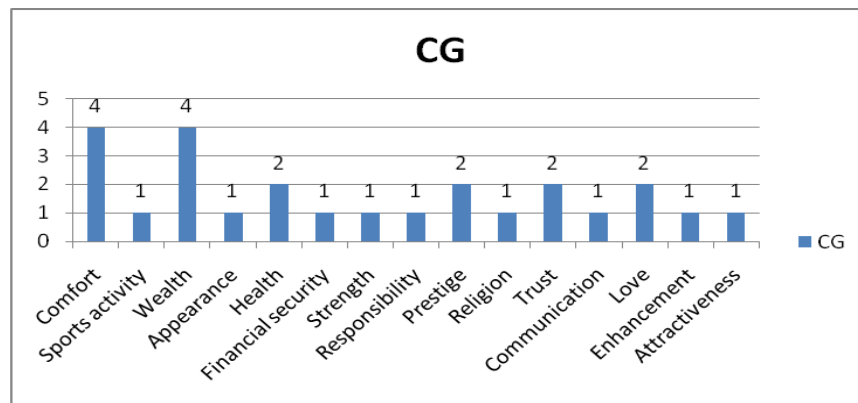


Figure 2 - The highest priority for the control group (CG)

The comparative results of the selection of LPO of the control group (CG) and experimental group (EG) are presented in Figure 3.

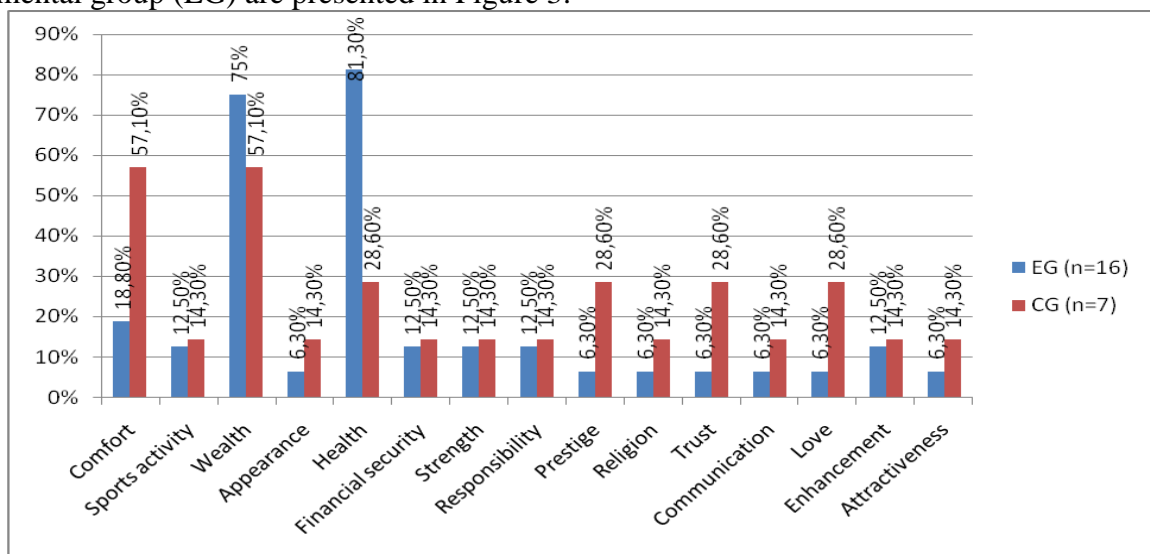


Figure 3 - The comparative results of the selection of LPO of the control group (CG) and experimental group (EG)

The data were processed using the multifunctional criterion Fisher's ϕ^* (Fisher's angular transformation). The results of the processing on a computer using SPSS software have shown that the differences between the life values of the interviewed in the control and experimental groups are reliable (for the significance point $p < 0.05$) "health", which testifies that the "life and value" systems of the experimental group differs them greatly from the control group on the degree of filling their professional life and sports with content.

The comparative results of the control and experimental group (LPO) are presented in Table 1.

Table 1 - The comparative results of the control and experimental group of LPO

	EG (n=16)	CG (n=7)	ϕ^*	ϕ cr.	P
Comfort	18.8%=3	57.1 %=4	1.806	1.64	$p > 0.01$
Sports activities	12.5%=2	14.3%=1	0.116	1.64	$p > 0.05$
Wealth	75%=12	57.1%=4	0.839	1.64	$p > 0.05$
Appearance	6.3%=1	14.3%=1	0.595	1.64	$p > 0.05$
Health	81.3%=13	28.6%=2	2.467	2.31	$p < 0.01$
Finances	12.5%=2	14.3%=1	0.116	1.64	$p > 0.05$
Strength	12.5%=2	14.3%=1	0.116	1.64	$p > 0.05$
Responsibility	12.5%=2	14.3%=1	0.116	1.64	$p > 0.05$
Prestige	6.3%=1	28.6%=2	1.374	1.64	$p > 0.05$
Religion	6.3%=1	14.3%=1	0.595	1.64	$p > 0.05$
Trust	6.3 %=1	28.6%=2	1.374	1.64	$p > 0.05$
Communication	6.3%=1	14.3%=1	0.595	1.64	$p > 0.05$
Love	6.3%=1	28.6%=2	1.374	1.64	$p > 0.05$
Enhancement	12.5%=2	14.3%=1	0.116	1.64	$p > 0.05$
Attractiveness	6.3 %=1	14.3%=1	0.595	1.64	$p > 0.05$

As we can see in Table 1, the priority of live values for the interviewed in control and experimental groups is different. The "comfort" criterion was observed in 57.1% of the interviewed in the CG and only in 18.8% of the interviewed in the EG. The criterion "wealth" is important for 57.1% of the interviewed in CG, however it was observed in 75% of the interviewed in the EG. A very considerable difference was obtained when evaluating such life important criterion as "health": 81.3% - in the experimental group and 28.6% - in the control group.

The methodology to determine the temperament was applied to study the individual peculiarities of handball players from the point of view of neuroticism, extraversion and introversion.

The results of the interviews with the handball players in the experimental group (EG) have shown that 50% of players belong to choleric-melancholic, 37.5% - choleric and 12.5 - sanguine - choleric. The data is presented in Table 2.

Table 2 - The results of the methodology to determine the temperament in the EG

Player №	Temperament type	Extraversion	Neuroticism
1	Choleric	Potential extrovert	Potential discordant
2	Choleric-Melancholic	Ambivert	Potential discordant
3	Sanguine-Choleric	Potential extrovert	Normostenic
4	Choleric	Potential extrovert	Potential discordant
5	Choleric	Potential extrovert	Potential discordant
6	Choleric-Melancholic	Ambivert	Potential discordant
7	Choleric-Melancholic	Ambivert	Potential discordant
8	Sanguine-Choleric	Potential extrovert	Normostenic
9	Choleric	Potential extrovert	Potential discordant
10	Choleric-Melancholic	Ambivert	Potential discordant
11	Choleric	Potential extrovert	Potential discordant
12	Choleric-Melancholic	Ambivert	Potential discordant
13	Choleric-Melancholic	Ambivert	Potential discordant
14	Choleric-Melancholic	Ambivert	Potential discordant
15	Choleric-Melancholic	Ambivert	Potential discordant
16	Choleric	Potential extrovert	Discordant

As we can see in Table 3, 71% of the interviewed in the control group (CG) were choleric, 29% were choleric-melancholic.

Table 3 - The results of the methodology to determine the temperament in the CG

Player №	Temperament type	Extraversion	Neuroticism
1	Choleric	Potential extrovert	Potential discordant
2	Choleric	Potential extrovert	Discordant
3	Choleric-Melancholic	Ambivert	Super-discordant
4	Choleric-Melancholic	Ambivert	Super-discordant
5	Choleric	Potential extrovert	Super-discordant
6	Choleric	Potential extrovert	Super-discordant
7	Choleric	Potential extrovert	Discordant

The analysis of the results of the conducted study of temperament properties according to H. Eysenk has not shown any considerable differences on the temperament properties between the control and the experimental groups, both groups were homogeneous. At the same time a more distinct inclination towards neuroticism was observed in the control group.

The methodology of testing the personality for the motivation to succeed allowed to determine the motivation to succeed in handball players of the both groups. Table 4 shows the data on the experimental group (EG).

Table 4 - The results of the methodology for diagnostics of a personality for the motivation to succeed in the EG

EG	Points	Motivation degree
1	26	Very high
2	14	Average
3	13	Average
4	23	Very high
5	24	Very high
6	25	Very high
7	22	Very high
8	25	Very high
9	21	Very high
10	24	Very high
11	24	Very high
12	27	Very high
13	24	Very high
14	22	Very high
15	21	Very high
16	26	Very high

Table 5 shows the results, obtained in the control group (CG).

Table 5 - The results of the methodology for diagnostics of a personality for the motivation to succeed in the CG

CG	Points	Motivation degree
1	21	Very high
2	15	Average
3	19	Moderately high
4	17	Moderately high
5	18	Moderately high
6	15	Average
7	19	Moderately high

The final parameter of motivation to succeed in both groups was obtained by mathematical addition of points. The sum of points from 11 to 15 means - the average motivation degree; at points sum from 16 to 20 - moderately degree of motivation; at 21 points and above - very high degree of motivation. Correspondingly the higher the sum of points of the interviewed, their his motivation to succeed is.

The data were processed using the multifunctional criterion Fischer's. The comparative results of the control and experimental groups according to the Methodology for diagnostics of motivation to succeed are given in Table 6:

	EG (n=16)	CG (n=7)	φ^*	φ cr.	P
Very high	87.5%=14	14.3%=1	3.627	2.31	p<0.01
Average	12.5%=2	28.6%=2	0.894	1.64	p>0.05
Moderately high	-	57.1%=4	-	-	-

The performed analysis has shown that the difference between the assessment of motivation to succeed for the interviewed in the control and experimental groups are reliable (for the significance point $p < 0.05$), testifies that the degree of the motivation is considerably higher in the experimental group.

The methodology of the personal diagnostics to study the motivation to avoid failures allowed to determine the motivation of the handball players to avoid failures. The data, obtained in the experimental group (EG) are given in Table 7.

Table 7 - The results of the methodology for diagnostics of a personality for motivation to avoid failures in the EG

EG	Points	Motivation degree
1	14	Average
2	14	Average
3	15	Average
4	16	Average
5	13	Average
6	12	Average
7	17	High
8	19	High
9	17	High
10	18	High
11	14	Average
12	18	High
13	12	Average
14	16	Average
15	17	High
16	14	Average

Table 8 shows the results, obtained in the control group (CG).

Table 8 - 7 - The results of the methodology for diagnostics of a personality for motivation to avoid failures in the CG

CG	Points	Motivation degree
1	19	High
2	16	Average
3	20	High
4	17	High
5	20	High
6	15	Average
7	18	High

The final parameter of motivation to avoid failures in both groups was obtained by mathematical addition of points. The sum of points from 2 to 10 means low motivation, from 11 to 16 - average degree of motivation; from 17 to 20 - high degree of motivation, more than 20 – very high degree of motivation. Correspondingly the higher the sum of points of the interviewed, the higher his desire to avoid failures is, and correspondingly he risks less in his play activity.

The data were processed using the multifunctional criterion Fischer's. The comparative results of the control and experimental groups according to the Methodology for diagnostics of motivation to avoid failures are given in Table 9.

Table 9 - The comparative results of the control and experimental group of the methodology for diagnostics of motivation to avoid failures

	EG (n=16)	CG (n=7)	ϕ^*	$\phi_{cr.}$	P
High	37.5%=6	71.4%=5	1.535	1.64	p>0.05
Average	62.5%=10	28.6%=2	1.535	1.64	p>0.05

As we can see in Table 9, the motivation of the interviewed in control and experimental groups to avoid failures is different. This proves that the activity of the highly qualified handball player forms the attitude for highly effective activity, and the striving for success prevails over the striving to avoid failures.

Conclusions

1. The results of the study using the LPO methodology have shown that the priority of life values of the highly qualified hand-ball players (EG) and reserve handball players (CG) differ. The most considerable differences were obtained in three criteria: "comfort", "wealth" and "health". The criterion "comfort" was observed in 57.1% of the interviewed in the CG and only in 18.8% of the interviewed in the EG. The criterion "wealth" was important for 57.1% of the interviewed in CG, but for the interviewed in the EG it was important for 75% of the interviewed. The most considerable difference between the importance was obtained during the evaluation of the criterion "health": 81.3% - in EG and 28.6% - in CG.

2. The results of the study, using the temperament identification methodology, allowed to draw a conclusion that the control and the experimental groups of the interviewed were homogeneous, and considerable differences between them on the temperament properties were not observed. At the same time the interviewed from the CG a more distinct inclination to neuroticism than the EG.

3. The results of the study using the Methodology for diagnostics of the personality's motivation to succeed and Methodology for diagnostics of the personality's motivation to avoid failure have shown that the degree of motivation to succeed and motivation to avoid failures for the interviewed in control and experimental groups differs. This proves that the attitude for highly effective play activity prevails for the highly-qualified handball players, and besides the striving for success prevails over the striving to avoid failures. In CG (reserve handball players) on the contrary are more disposed to motivation to avoid failures, rather than motivation to succeed.

FOULS IN WOMEN'S TEAM HANDBALL - THE EFFECT OF A PERMITTED FOUL ON DEFENSE PERFORMANCE

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Summary

The aim of the defense in team handball is to prevent the opponent team from scoring. One coaching strategy could be to interrupt the offense with permitted fouls to achieve this aim. In the present study the effectiveness of a permitted foul on the rate of success of defending goals in women's team handball was evaluated. In addition, we conducted an expert-novice comparison between German professional leagues and amateur leagues.

Keywords: team sports, coaching strategy, tactics, foul, free-throw

Introduction

The primary game idea of team handball is to score a goal while defending the own goal (e.g., Griffin and Butler, 2005). As team handball is characterized by dynamic movements, fast game play, and high numbers of one-on-one actions, a high number of fouls are inevitable. According to Daza (2017), the game structure of team handball can be divided into three important main phases: the attack (ball possession, trying to score), the defense, and the goalkeeping (both trying to prevent the opponent from scoring, trying to recover ball possession). Further, two sub-phases are differentiated: counterattacks (as sub-phase of the attack) and the fast back-up (as sub-phase of the defense; Karcher and Buchheit, 2014). Fasold and Redlich (2018) mentioned that different variables, like offence, defense, and the goalkeeper, have been considered as performance indicators, but the effect of permitted fouls on the performance is still unclear and warrants further investigation.

In team handball it is allowed to use body contact, as a defending technique, in order to keep the opponent at a distance from the own goal, as long as it is according to the rules (e.g., the use of upper arms, bent arms, the own trunk; International Handball Federation, 2016). This kind of body contact is used to get into and keep an optimal defending position without a personal punishment. If this body contact is not in line with the rules and leads to a turnover or a technical rule mistake by the attacking team, this action is called a foul, and it is sanctioned by a free-throw or a penalty and if necessary, an additional personal sanction (2 min. suspension, yellow card, red card). In the current paper we will label these kinds of fouls as permitted fouls (cf. Fasold & Redlich, 2018).

In free-throw situations defenders can always position themselves between the attacker and the own goal (according to the rules with a distance of 3 meters from the spot of the foul, International Handball Federation, 2016). Therefore, a free-throw cannot be seen as a situation favoring the attacking team, and thus, permitted fouls through body contact could be a promising strategy to interrupt the dynamics and the game flow of the opponent's attack and as a strategy to increase the success rate of the defense. But on the other hand, if a free-throw is called, the defense does not gain possession of the ball, which is why it could also be assumed that winning the ball without a foul could be a more adequate strategy for the defending team.

In order to measure player performance on the court, Brack (2002) and Marczinka (2013) developed two different match analytic systems to rate the actions of players in match situations. Both assigned a permitted foul with a positive value, so that a foul can be seen as having a positive impact on defense performance. Therefore, it could be assumed that a game interruption, by committing a permitted foul, is a positive factor in the game winning process. However, it should be mentioned, that both references do not provide a very clear definition of the foul. Therefore, this assumption must be treated with caution.

It can be assumed that the longer an attacking phase lasts the probability of a forewarning signal for passive play by the referee increases. This forewarning signal puts the attacking team under pressure, which should increase the defense success rate of the defending team. Studies show that female elite team handball players get into about 23 body contact situations (low-intensity contact, high-intensity contact, clasping) during a game (Michalsik et al., 2015). All these body contact situations can lead to an interruption of the game (referee call). These interruptions can extend the duration of an attacking phase and could increase the success of the defense.

According to Fasold & Redlich (2018), and in contrast to the previously mentioned findings which considered a permitted foul as a positive action, permitted fouls and defending without a foul show no effect on the defense success rate on an expert level (in male handball). The authors stated, in line with successful coaches, that fouls seem to be useful only under specific conditions (e.g., depending on zones, situations).

In general, the knowledge of whether permitted fouls influence the effectiveness of the defensive performance is merely based on game-specific experiences. Further, there is a lack of empirical validations of these foul behaviors, in particular in women's handball, which makes it difficult to make recommendations for sports practice. Thus, it still remains unknown whether a permitted foul is an effective tool for successful defense in women's team handball or not.

The current study was conducted to investigate the relation between permitted fouls and successful defending (i.e., the prevention of goal situations of the attacking team) and to compare the effectivity of the two approaches: defending with a permitted foul or without a foul, in women's team handball in Germany. The current study was conducted based on the study of Fasold and Redlich (2018), who investigated a similar topic in men's team handball. Even though the authors did not find significant results when comparing the success rate of the defense when using a permitted foul or no foul in their study, there may still be differences in women's team handball because of the different physical demands. Women's team handball features less intense tackling and game dynamics (measured in activity changes; Michalsik, 2015), which could be an indicator for different defending tactics and effectivity of permitted fouls.

Methods

The data was collected via post-hoc video analyses. Thirty matches of female professional team handball from a single season (2017/2018) of the 1st, 2nd and the four 3rd leagues (north, east, south, west) in Germany as well as 20 matches of German amateur team handball leagues (4th and 7th league) were analyzed (N = 50). Only matches with a maximum difference of four goals in the final match result were chosen in order to obtain results from balanced matches. Ten matches of each of the aforementioned leagues and a total of 3.950 different attacking situations (an attacking situation was defined as a situation in which no changes in ball possession occur) were analyzed. To include a high number of different teams in the analysis, a maximum of two matches of each team was included in the analysis.

Only attacking situations against organized defenses in 6 vs. 6 situations were considered. Furthermore, only situations in which all defensive players were positioned between the attacking team and the goal to be defended while the ball was crossing the middle-line were included. Thus, all other match situations (e.g., 6 vs. 5, 5 vs. 6, 5 vs. 5, etc.) and all kinds of counter attacks/back-up phases were excluded from the analysis. If a situation was sanctioned with a 2-minute suspension without a 7-meter penalty, the action remained in the analysis, but the situation afterwards was excluded because of the unequal number of players on the court.

The remaining situations were analyzed with regard to the objective frequency variables: defense outcome (goal /no goal), foul (yes/no), and suspensions (yellow card/red card/ 2 minutes).

The evaluation of the video footage and the preparation of the collected data were conducted by an experienced handball player and coach (B-license of the German Handball Federation and more than twelve years of experience in playing senior league).

2x2 tables were used to test the general distribution of the variables and to measure the frequencies of the independent factors on the frequencies of the dependent variables. A χ^2 -Test was performed to conduct the statistical frequency comparison.

Results

The final analysis consisted of 3.950 defensive situations (2.433 of the elite level and 1.517 of the amateur level).

Elite level

In elite team handball, the defending team interrupted attacking situations in 40.98 % of the observed situations by committing a foul (measured on referee calls). In 4.02 % of the calls the referee sanctioned an interruption with a yellow card, and in 4.48 % of the calls the referee sanctioned an interruption with a 2-minute suspension.

The frequency of the goal vs. no goal situations in dependence of the foul vs. no foul situations was compared (Fig. 1). No (statistically relevant) difference was found between the success rate of the defense between situations in which a permitted foul was implemented and those in which it was not, $\chi^2(1) = 0.47, p = .49$.

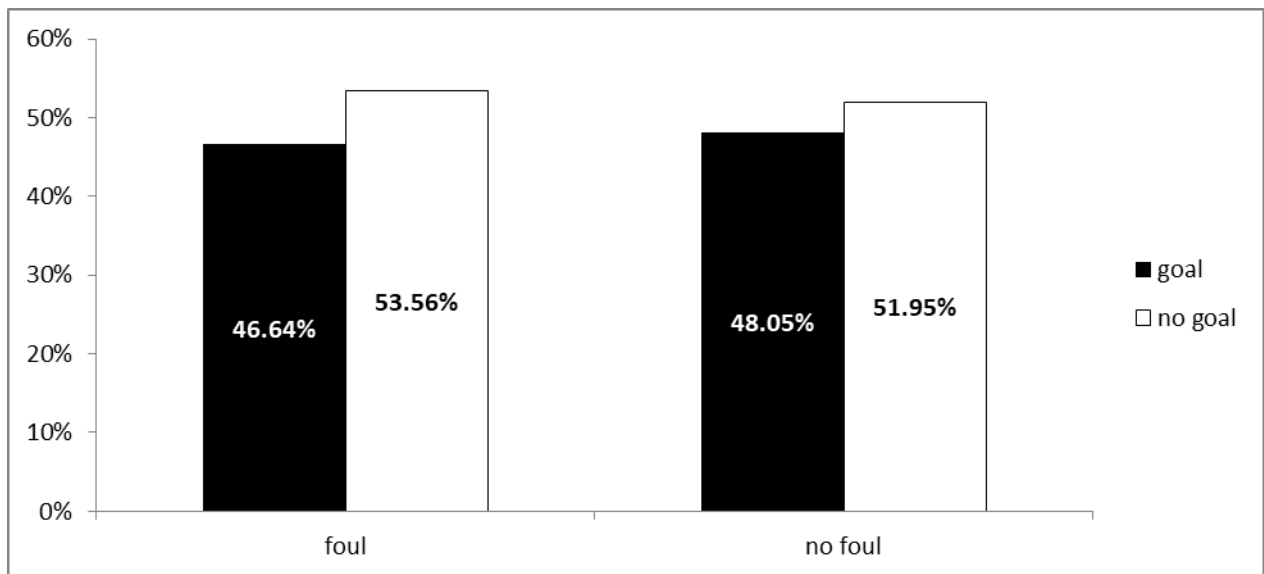


Figure 1: Frequency distribution (%) for the events goal and no goal for defensive actions with a foul ($n = 997$) and without a foul ($n = 1.436$) in women elite team handball.

As the different elite leagues were compared, the results showed that in the 1st German Bundesliga there was an influence of permitted fouls on the success rate of defending. When the defense interrupted the offense the probability of scoring a goal became less likely (33.96 %) than the probability of scoring when the offense was not interrupted ($\chi^2(1) = 7.47, p=.01$). In the 2nd league the same tendency for a decrease in the probability of scoring after an interruption was found (41.20 %) but this result was not significant, $\chi^2(1) = 0.24, p=.63$. Also, in the four 3rd leagues the same small tendency for a decreased probability of scoring after a permitted foul was found (45.85 %), but no significant effects between the variables, $\chi^2(1) = 1.08, p=.30$.

Amateur level

In amateur team handball, the attacking team was interrupted in 48.82% of all cases by a permitted foul. In 3.75 % the foul was sanctioned by a yellow card, and in 2.17 % the referee sanctioned a foul by a 2-minute suspension.

Like for elite team handball, the frequency of the goal vs. no goal situations in dependence of the foul/no foul situations was compared. As can be seen in Figure 2, the probability of defending a goal in a foul/no foul situation was quite different to the elite level. In amateur leagues it was more likely that the attacking team scored after an interruption by a permitted foul committed by the defense, $\chi^2(1) = 6.65, p=.01$.

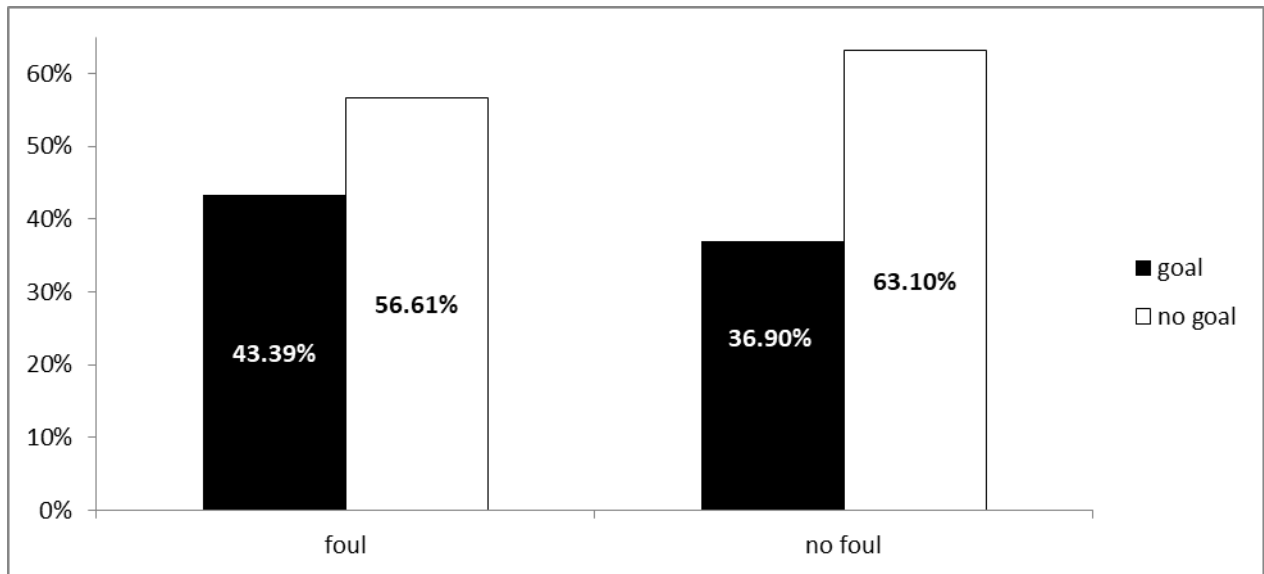


Figure 2. Frequency distribution (%) for the events *goal* and *no goal* for defensive actions with a foul ($n = 742$) and without a foul ($n = 775$) in women amateur team handball.

With regard to the different leagues one can see that no significant results were found in the 4th league, $\chi^2(1) = 0.97, p = .33$, for scoring after the defense interrupted the offense (44.44 %) but highly significant results were found in the analysis of the 7th league, $\chi^2(1) = 8.10, p = .00$, for successful attacks after an interruption through the defense (61.59 %).

Discussion

The results in women elite team handball are overall quite similar to the results of the previous study conducted by Fasold and Redlich (2018) in men elite team handball. The current results in women team handball do also not support the assumption that a permitted foul is a better way to stop the opponent team from scoring than no foul. In women amateur handball the distribution shows differences in relation to the female elite team handball as well as in comparison to the results of Fasold and Redlich (2018). It seems that there might be differences in the defending strategies between the different playing levels of the teams.

The significant results which were found in the amateur league in team handball are critical. Because of the difference of the leagues from the 4th to the 7th league, the results cannot be considered as valid; it seems that the differences in playing performance are way too high to summarize both leagues as the same expertise level (amateur). Thus, the highly significant results that were found in the 7th league could influence the results of the 4th league and led to the significant findings for the expertise level (amateur). At this point it could be beneficial to analyze leagues that are not as different with regard to playing performance and level.

Significant results were found in the amateur league as well as in the 1st German league. In the 1st league it is more likely to prevent the attacking team from scoring by committing a foul. In the amateur league the opposite is the case. Here, a foul seems to be a bad option for the defense, because the attacking team is more likely to score a goal after a permitted foul was committed. These opposite results could be explained by the different performance levels. An attacking situation in an amateur league could result in hurried shots due to the advancing attacking time and missing experience when there is no interruption. While, an interruption in elite leagues

could lead to a longer attacking time which could result in the forewarning of passive play and consequently in hurried shots. In elite leagues a hurried shot (bad shooting position) without forewarning of passive play could occur less often than in amateur leagues because of the performance level and the experience of the players. Future research should focus on the effectivity of permitted fouls in connection to forewarning of passive play in depth.

The significant findings in the 1st league in women team handball could confirm the assessment of Brack (2002) and Marczinka (2013), evaluating permitted fouls as positive actions concerning defensive performance. But it cannot be assumed that this is the case in general. The findings of Fasold and Redlich (2018), for example, are not in line with this assumption. It seems that there is a difference between men and women elite team handball regarding successful defending strategies. A possible reason for this could be the different physical demands and game dynamics (Michalsik, 2015). Thus, another possible avenue for future research could be the investigation of whether the effectivity of a permitted foul depends on the different physical demands and abilities in team handball.

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POSTER PRESENTATIONS

IMPLICATIONS OF A LINEAR FORCE-VELOCITY RELATION ON COMPLEX MOVEMENTS. A PRELIMINAR STUDY WITH THROWING

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Summary

Handball, like many other sports, routinely includes intense weight training sessions. If not done carefully, one may ask if we are not exchanging agility and speed by brute force. This balance is relevant to several abilities including the throwing capacity/speed and can be accessed with a simple linear force-velocity model and a spreadsheet.

The preliminary results show that the evaluated players were not on the speed side of things.

Introduction

One of the main physical performance determinants for successful shooting is the throwing velocity, along with its accuracy. Two of the main factors that influence the throwing velocity are both power and strength (Gorostiaga et al., 2005; Ortega-Becerra et al., 2018). The Samozino et al. (2011) work showed that it is the balance of force versus velocity that is relevant, if all else is constant. These authors studied the performance of jumping and realized that athletes with the same maximal power and same push-off distance can achieve different results. They relate these differences with the respective force-velocity profiles. Several studies have suggested that, in maximum performance multi-joint movements, this force-velocity relationship might be linear (Cuk et al., 2014; Morin & Samozino, 2015; Morin et al., 2010; Samozino et al., 2012; Sreckovic et al., 2015). Therefore, from a theoretical point of view it is possible to measure the individual muscular force-velocity profile and compare it to an optimal profile that would maximize final throwing velocity (Jimenez-Reyes et al., 2017; Samozino et al., 2008; Samozino et al., 2012). Thus, and as showed by Jimenez-Reyes et al. (2017), some athletes show a force-velocity imbalance in favour of force (velocity deficit) and others show an imbalance in favour of velocity (force deficit). These authors tested a training program and concluded that an individualized program addressing these imbalances is more efficient at improving jump performance than a traditional resistance strength-training program common to all athletes, regardless of their profiles. Prior to the theorization about power-force-velocity individualization done by Samozino et al. (2012) there were already empirical studies about the relation between ball weight and throwing distance, on an *average population*. Tillaar & Ettema (2004) studied this relationship applied to overarm throwing with seven balls (circumference 0.3 m) with different weights (ranging from 0.2kg to 0.8kg), and found a linear relationship between force and velocity.

The determination of the power-force-velocity profile seems to be a promising aspect for individual training optimization in ballistic movements. Therefore, if coaches intend to develop shooting/passing speed, then they should be aware of each player's needs, from a muscular-mechanical perspective and playing position specificity.

The purpose of this study is to test an experimental protocol attempting to identify the deficits and, consequently, the necessities of each player in order to improve shooting velocity.

Methods

We have organized a simple (field implementable) protocol to evaluate the force vs velocity dichotomy with respect to the throwing capacity and applied it to ten adult male players of a team of the Portuguese Second Division.

The protocol uses a set of six balls with official sizes (1, 2 and 3) but with weights ranging from 298g to 818g. Each player performed several 7-metre throws to the goal with these balls (in randomized order) and the ball speed was measured with a handheld radar.

Table 7 – Ball sizes used in the study

Size	Size 1	Size 2	Size 3	Size 3	Size 3	Size 3
	Official	Official	Official	Modified	Modified	Modified
Weight (g)	298	337	433	536	741	818

Development

There is a long stream of experimental evidence that complex movements follow a linear force-velocity relation when seen at an appropriate range (not too extreme). This is also evident from an analytic perspective as any smooth curve, at a small enough scale, is always well approximated by a straight line.

We have studied the balls' average throwing force vs the ball velocity when exiting the hand and encountered this linear relation. Underlying data was obtained with a radar.

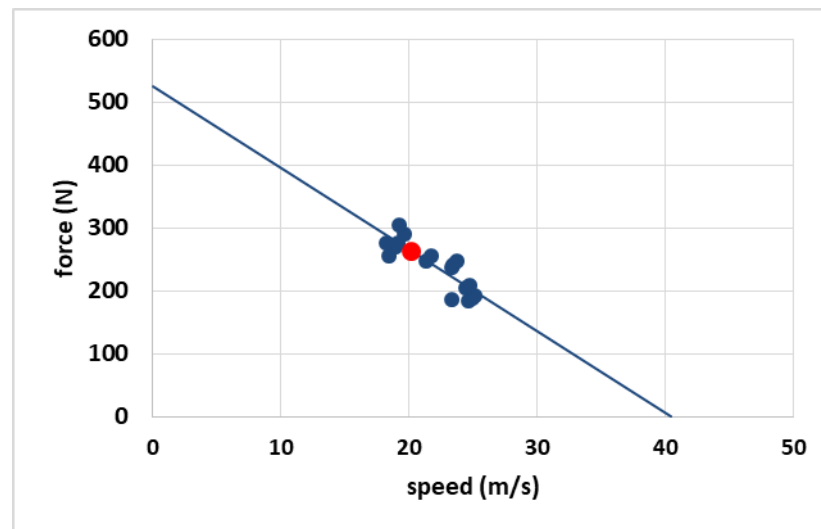


Figure 4 - Sample of a throwing force-velocity profile

The consequence of this linear force-velocity relation is a parabolic (quadratic) relation between power and force

$$F = c \cdot v + b$$

$$P = F \cdot v$$

$$P = cv^2 + bv$$

or

$$P = \frac{1}{c}F^2 - \frac{b}{c}F$$

At any technical sport extreme loads are an injury risk. The apparatus (the balls in handball) should be fairly *adapted* to the average players. This means that the diameter of the ball should be adapted to the typical hand size. Also the mass of the ball must not be too small (allowing extreme throwing velocities) nor too heavy, both of which pose a risk to the muscle-skeletal system of the arm. We assert that the ball that has a mass nearest to the peak of the power-force curve is the most adapted ball to the players.

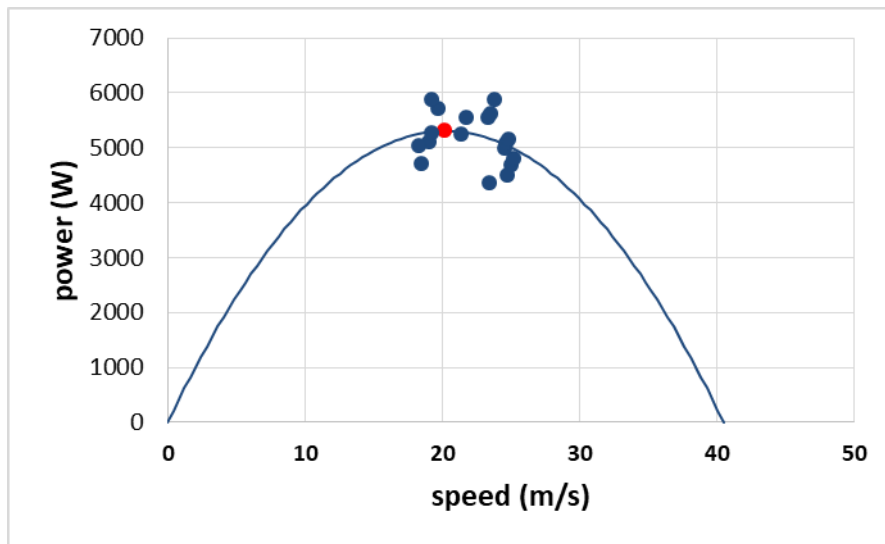


Figure 5 - Sample of a power-velocity profile

In this paper we show very preliminary results of the exploration of these ideas. These, as well as other still unpublished results, support the notion that we should use slightly heavier (and smaller) balls.

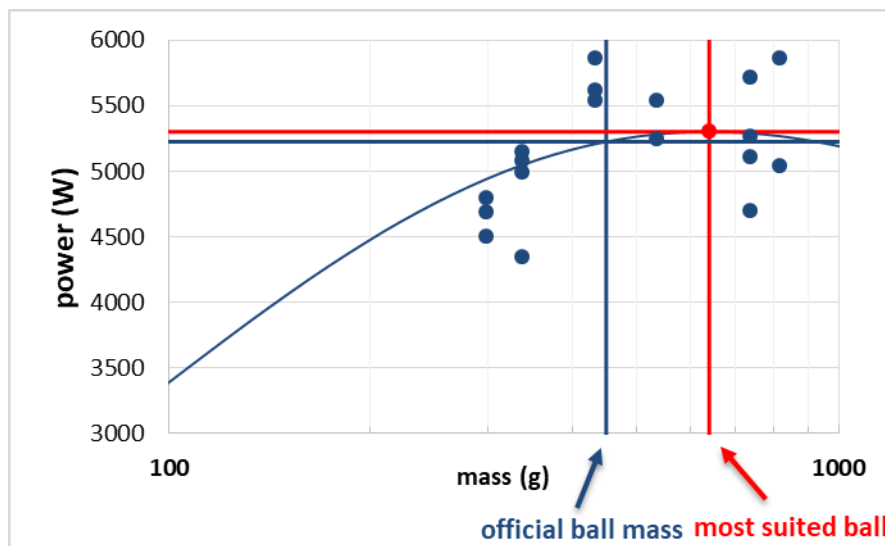


Figure 6 - The balls that promote a higher average throwing power are heavier than the standard

Our preliminary results support the adoption of a ball with around 640g, according to this principle of maximizing power. They will not reduce (or increase) significantly the throwing velocity but are more adapted to the players, possibly reducing the overuse injuries.

Conclusions

Results also show that all players would produce higher throw power if the ball was heavier than the official size 3, meaning that they have a speed deficit. They need to improve speed more than they need to improve shear force. This information is important to the design of adequate training sessions, adjusted to individual needs.

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EFFECT OF ANKLE TAPING ON KNEE AND HIP JOINT ANGLES DURING JUMP LANDING TASKS

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Summary

The purpose of this study was to investigate the effect of ankle taping on knee and hip joint angles during landing from three step run-up followed by jumping. 22 female collegiate recreational athletes volunteered to perform two jump landing tasks and a stopping task with maximal effort. The sum of knee and hip flexion angles of the ankle-taped leg was significantly greater than the untaped.

Keywords: anterior cruciate ligament, ankle-taping, jump-landing, lower extremity joint angle

Introduction

Anterior cruciate ligament (ACL) injuries are 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). Younger female athletes, especially, are about 2 to 5 times more likely to suffer ACL injuries compared to male athletes (Africa et al. 2017). Considering those with knee injuries such as ACL or meniscus tear have a high risk of osteoarthritis (Lohmander et al. 2007), ACL injuries exert 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 injuries.

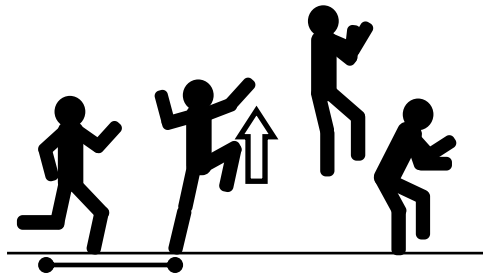
The ACL restrains the tibia from translating anteriorly. The ACL loading depends on the anterior shear force affected by the posterior ground force and knee flexion angle (Dai et al. 2014). Smaller knee flexion angles and greater quadriceps activation are correlated (Walsh et al. 2012). The peak impact posterior ground reaction force is correlated to the peak impact knee extension moment and the proximal tibial anterior shear force (Yu et al. 2006). A straight landing posture produces greater posterior ground reaction forces than a flexed posture (Daneshjoo et al. 2015). Also, it has been indicated that a decreased hip flexion, an increased internal rotation of the hip and an increased external rotation of the tibia reduce the stability in the knee joint as risk factors for ACL injuries (Africa et al. 2017).

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. It was hypothesized The knee and hip joint motion would be greater when the range of ankle joint motion was restricted with use of ankle taping. Several researches have investigated the biomechanical effect of ankle bracing during a drop-jump task. Past research demonstrated ankle taping reduced internal rotation moments and varus impulses during running and sidestepping (Stoffel et al. 2010). 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 jumping-up. Therefore, the purpose of this study was to evaluate the differences between ankle-taped and untaped legs in knee and hip joint angles during two landing and one stopping tasks. In the previous study, it was shown ankle taping could increase knee and hip flexion angle during jump-landing using 2D analysis (Fukuda et al. 2017). The 3D analysis was conducted in this study.

Method

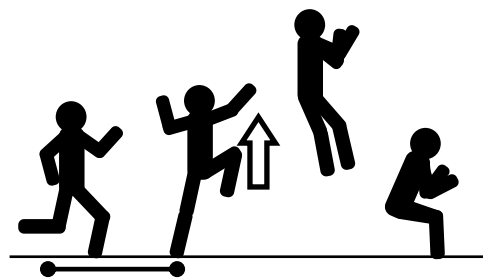
Subjects: Twenty two healthy female collegiate recreational athletes (age=18.26±0.45years, height=161.07±5.74cm, body weight=56.49±8.52kg) volunteered to participated in this investigation. All subjects regularly played sports such as basketball, badminton or lacrosse. Subjects had no history of chronic lower limb injury and no lower limb injury within last six months. Institutional review board approval and informed consent forms were obtained prior to collecting data.

Procedures: Subjects were instructed to warm-up and practice 3 landing tasks: 1) single (preferred) -leg landing (Figure 1), 2) double-leg landing from a vertical jump (Figure 2) and 3) double-leg stopping from a horizontal jump followed by a vertical jump (Figure 3) with three-step run-up off one preferred foot for 10 minutes before video-recording. Subjects performed 3 trials for each task at maximal effort without ankle taping, first. Ankle taping, 38mm Johnson and Johnson Coach® adhesive tape (Princeton, NJ, USA), was bilaterally applied to each participant 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, next. All measurements were collected using a three-dimensional motion analysis system with 28 retroreflective markers and 6 digital cameras at 120 Hz (Oqus 300 Qualisys medical AB, Gothenburg, Sweden). The markers were bilaterally secured on anterior superior iliac spine, posterior superior iliac spine, greater trochanter, the 1/3-distal lateral aspect of femur, medial and lateral femoral epicondyles, medial and lateral tibial condyles, tibial tuberosity, the 1/3-distal lateral aspect of fibula, medial and lateral malleoli, head of 2nd metatarsal, head of 5th metatarsal and tuberosity of calcaneus. The kinematic data of 6 (out of 18 successful trials) best trials were exported to Visual 3D (C-motion Inc., MD, USA) for analysis. A trial was not considered as a successful trial if: the subject lost balance and fell on the floor during the tasks; a retroreflective marker fell off; or the trial was interrupted. The best trial was defined as trial in which subject vertically or horizontally jumped the most among 3 successful trials each task. The kinematic measurements analyzed were the peak knee flexion angle, the peak valgus angle, the peak tibial internal rotation angle, the peak hip flexion angle and the peak hip internal rotation angle.



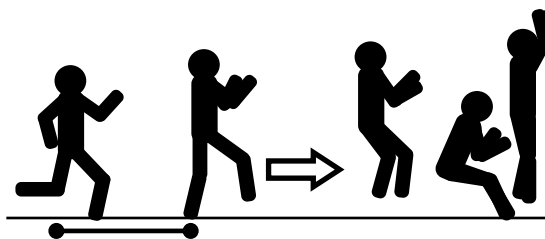
3-step runup

Figure 1. Single-leg landing task: the subject performed three-step run up followed by vertically jumping off one preferred foot and one-footed landing. The subject was allowed to use the second foot for safety in case losing balance and falling on the floor.



3-step runup

Figure 2. Double-leg landing task: the subject performed three-step run up followed by vertically jumping off one preferred foot and two-footed landing.



3-step runup

Figure 3. Double-leg stopping task: the subject performed three-step run up followed by horizontally jumping off one preferred foot and two-footed landing, and vertically jumping off the landing point immediately after landing.

Statistical analysis: All data obtained are shown as mean \pm SD. The data was calculated statistically 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 24.0 Statistical Base, SPSS, Inc., Chicago, IL, USA) was used.

Results and Discussions

4 out of 22 subjects who had incomplete 3-D motion analysis data due to technical problems were excluded. The results are shown in Table 1, Table 2, Table 3 and Figure 4. Although ankle taping did not increase both peak knee angle and peak hip flexion angle, peak sum of knee and hip flexion was significantly increased during the single-leg landing ($p < 0.05$). The obtained data implied the subjects were divided into two characteristic groups as for landing. One preferred to land with flexing knee more and keeping hip flexion still, and the other landed with the opposite. It could have been the landing characteristic caused peak knee and hip flexion angle of the taped were not greater than the untaped. The differences of peak valgus, tibial internal rotation and hip internal rotation between the taped and the untaped were not significant.

Table 1. Kinematic angles during the single-leg landing from a vertical jump

variable	session		<i>p</i>
	untaped	taped	
Peak knee flexion	99.86 \pm 16.94	101.09 \pm 16.99	n.s.
Peak hip flexion	57.33 \pm 17.81	63.07 \pm 22.08	n.s.
Peak sum of knee and hip flexion	154.06 \pm 32.19	162.31 \pm 33.19	< 0.05
Peak valgus	4.23 \pm 8.25	3.30 \pm 6.78	n.s.
Peak tibial internal rotation	4.86 \pm 7.11	5.88 \pm 8.64	n.s.
Peak hip internal rotation	11.02 \pm 12.56	9.83 \pm 10.14	n.s.

Limited ankle motion due to taping significantly increased peak angles of both legs on all flexion measurements during the double-leg landing. Peak angles of valgus, tibial internal rotation and hip internal rotation of both taped legs were not greater than the untaped, however.

Table 2. Kinematic angles during the double-leg landing from a vertical jump

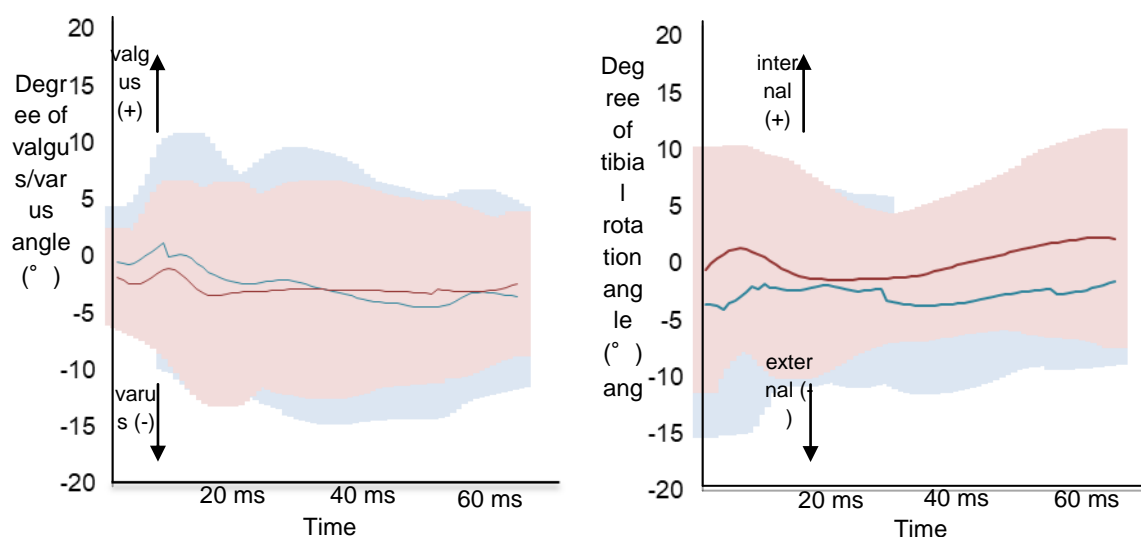
variable	session		<i>p</i>
	untaped	taped	
Peak knee flexion of left leg	93.08 \pm 14.75	101.01 \pm 19.56	< 0.01
Peak knee flexion of right leg	95.17 \pm 15.30	99.97 \pm 18.85	< 0.05
Peak hip flexion of left leg	73.42 \pm 17.41	77.71 \pm 15.64	< 0.05
Peak hip flexion of right leg	74.02 \pm 17.15	77.82 \pm 14.48	< 0.01
Peak sum of knee and hip flexion of left leg	165.80 \pm 29.74	178.28 \pm 32.01	< 0.01
Peak sum of knee and hip flexion of right leg	168.31 \pm 29.84	177.34 \pm 30.09	< 0.01
Peak valgus of left leg	3.61 \pm 6.42	6.30 \pm 6.99	n.s.
Peak valgus of right leg	2.28 \pm 5.72	3.55 \pm 6.48	n.s.
Peak tibial internal rotation of left leg	5.65 \pm 8.53	5.11 \pm 6.47	n.s.
Peak tibial internal rotation of right leg	4.81 \pm 6.06	5.01 \pm 5.82	n.s.
Peak hip internal rotation of left leg	11.07 \pm 8.59	12.71 \pm 7.73	n.s.
Peak hip internal rotation of right leg	11.47 \pm 9.66	12.71 \pm 10.51	n.s.

Peak knee flexion angles of both taped legs and peak sum of knee and hip flexion of the taped right leg were significantly greater than the untaped during the double-leg stopping. The use of ankle taping did not increase peak valgus, tibial internal rotation and hip internal rotation of both legs, as well as other tasks.

Table 3. Kinematic angles during the double-leg stopping from a horizontal jump

variable	session		<i>p</i>
	untaped	taped	
Peak knee flexion of left leg	95.72±20.02	98.53±23.42	< 0.05
Peak knee flexion of right leg	97.26±21.78	101.15±22.46	< 0.05
Peak hip flexion of left leg	72.43±16.37	74.79±15.60	n.s.
Peak hip flexion of right leg	71.88±16.83	74.49±14.89	n.s.
Peak sum of knee and hip flexion of left leg	166.78±34.34	168.70±37.52	n.s.
Peak sum of knee and hip flexion of right leg	167.77±37.31	173.99±35.99	< 0.05
Peak valgus of left leg	3.34±7.69	4.36±7.42	n.s.
Peak valgus of right leg	4.82±8.35	5.03±8.72	n.s.
Peak tibial internal rotation of left leg	5.17±6.45	5.70±6.03	n.s.
Peak tibial internal rotation of right leg	5.08±5.93	5.00±5.78	n.s.
Peak hip internal rotation of left leg	10.78±10.33	13.67±11.88	n.s.
Peak hip internal rotation of right leg	13.76±11.87	13.30±10.60	n.s.

Although ankle taping did not statistically produce the effects reducing peak valgus, tibial internal rotation and hip internal rotation angle during all tasks, there were trends toward decreased ranges of valgus/varus motion and hip rotation and increased tibial internal rotation during the single-leg landing. The trend in the current study indicated ankle taping improved



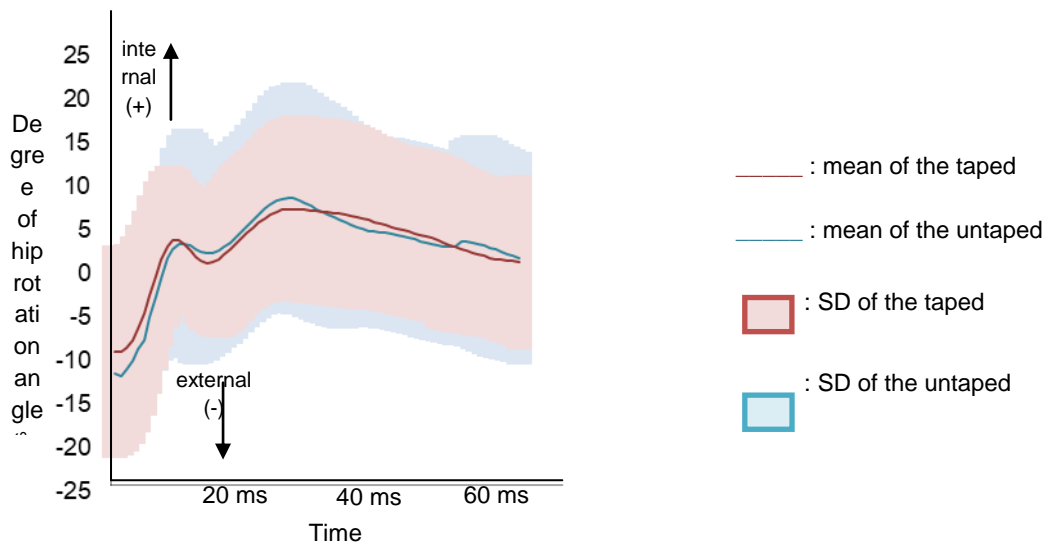


Figure 4. Kinematic angles during the single-leg landing.

single-leg balance during landing. 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. In addition, Pollard et al. (2010) suggested hip flexion helped knee flexing more and decreased valgus angle which led ground reaction force and valgus moment reduced. The results of this study indicated ankle taping could have been effective to reduce ACL injury risk in athletic tasks such as jump landing via increasing range of knee and hip flexion. However, Joseph et al. (2008) reported the use of ankle bracing reduced knee valgus angle related to ACL loading during drop jump. Moreover, Stoffel et al. (2010) demonstrated ankle taping decreased peak internal rotation moment peak varus moment at knee during sidestepping and running. In this study, there was no effect of ankle taping on valgus/varus angle and internal rotation angle at knee. Further investigations are required to clarify the effectiveness of ankle taping especially on ACL loading with monitoring ground reaction force during athletic tasks.

Conclusion

The results of the present study found that taped ankle increased flexion angles of lower extremity during landing and stopping from jump, compared with untaped ankle. This is likely due to limitation of ankle joint motion with ankle taping. Ankle taping could be positive to provide helpful posture to prevent ACL injury.

CONFLICTOMETRIC ANALYSIS OF INTERPERSONAL RELATIONS IN WOMEN'S HANDBALL TEAM

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Summary

Cohesion and a favorable socio-psychological climate is conducive to the growth of sports in the team. In this work, we have looked levels of conflict in interpersonal relations of handballers for an adequate analysis of the psychosocial climate and in the woman's team.

Keywords: the level of interpersonal conflicts, the coefficient of group and individual conflict, interpersonal conflict, handballers of high qualification.

Introduction

One of the most important characteristics of relationships in a sports team is the level (or degree) of conflict, both of an individual athlete and in the sports group as a whole.

Due to the fact that conflicts are an integral part of human life, it is necessary to give them the same comprehensive attention as other psychological aspects of everyday life. Recognizing that the conflict can lead to undesirable consequences, the possible damage caused by this phenomenon should be minimized and the greatest possible benefit from it [5].

According to the definition of the concept generally accepted for the sociology of sports, sport is a social phenomenon that includes competitive activity itself, preparation for it, and specific interpersonal relationships and behavioral norms that arise in the process of this activity. Accordingly, in essence, sports activities are inevitably associated with special relationships, including with conflicts. Modern sport makes high demands on the physical and mental capabilities of a person. The training and competitive process is often accompanied by the emergence of conflict situations that turn into either direct, open, conflict interaction, or into a hidden or intrapersonal conflict [2].

Close and effective interaction of teammates in sports and gaming activities is impossible under the conditions of a destructively expressed conflict interaction [3,4]. Acute prolonged conflicts between athletes destroy the system of business and personal ties, negatively stain interactions between group members, and ultimately lead to a decrease in sports results.

Methods

The purpose of the work was to identify the characteristic features of the level of cohesion and well-being of relationships, as well as the nature of interpersonal and informal relationships in the women's handball team.

To solve the aim of we used the following research methods:

- Analysis and synthesis of literary sources
- Pedagogical supervision
- Questioning

- Socio-psychological methods for determining interpersonal conflict (in particular: “Methodology for determining the level of interpersonal conflict” (B. A. Babayan),
- Methods of mathematical statistics (conflictometric index, median (Me), range of variation (R); conflict frequency index (J I.K) for the team as a whole and for each player separately).

Research results and discussion

One of the most important characteristics of relationships in a sports team is the level (or degree) of conflict, both of an individual athlete and in the sports group as a whole.

The indicator of group conflict (J I.K) of the women's handball team (calculated according to the method of B. A. Babayan) was -0.42 (with a range of J I.K from -1.0 to 1.0), which indicates the level of group Conflict is above average. The average Conflict Index of each player in the Me group (J.I.K.) = 0.2, indicates that the values of the individual conflict coefficient of the players as a whole are at the average value (which does not coincide with the value of the group coefficient (-0.42) of the conflict above).

Table 1 - Indicators of the group level of conflict

Frequency of conflict in the group							J (i.k.)	
Very often		Often		Seldom		Never		
Σ	P ₁ (%)	Σ	P ₂ (%)	Σ	P ₃ (%)	Σ	P ₄ (%)	
0	0,00	3	16,67	9	50,00	0	0,00	-0,28

J (i.k) - conflict frequency index;

P₁, P₂, P₃, P₄ - percentages of answers in the first, second, third and fourth variants of the answer, respectively.

However, for team players, the coefficient of individual conflict (Table 2) ranges from - 0,66 to 0,85, therefore, the conflict of players varies significantly within the same group. In this regard, we divided the players according to the level of individual conflict into 3 subgroups: the first K 1 (athletes with a conflict slightly higher than the average) - 3 athletes (16,7% of all group members); the second K2 (athletes with a conflict level of significantly average level) - 10 players (55,6% of the members of the whole group); the third K3 (athletes with low conflict) - 5 players (27,8%) of the members of the whole group.

Table 2 - Indicators of individual conflict handball players

No pl.	The frequency of the player's conflict in the opinion of the group									Subgroups by level of conflict (K)
	Very often		Often		Seldom		Never		J(i.k.)	
	Σ	P ₁ (%)	Σ	P ₂ (%)	Σ	P ₃ (%)	Σ	P ₄ (%)		
1.	5	27,78	8	44,44	5	27,78	0	0,00	-0,66	K1
2.	1	5,56	7	38,89	10	55,56	0	0,00	-0,50	
3.	0	0,00	9	50,00	7	38,89	2	11,11	-0,35	
4.	0	0,00	0	0,00	16	88,89	2	11,11	-0,18	K2
5.	0	0,00	2	11,11	13	72,22	3	16,67	-0,15	
6.	0	0,00	5	27,78	8	44,44	5	27,78	-0,05	
7.	0	0,00	4	22,22	9	50,00	5	27,78	-0,03	
8.	0	0,00	3	16,67	9	50,00	6	33,33	0,06	
9.	0	0,00	1	5,56	10	55,56	7	38,89	0,17	
10.	0	0,00	0	0,00	11	61,11	7	38,89	0,19	
11.	0	0,00	0	0,00	10	55,56	8	44,44	0,26	
12.	0	0,00	0	0,00	8	44,44	10	55,56	0,41	
13.	0	0,00	1	5,56	5	27,78	12	66,67	0,54	
14.	0	0,00	0	0,00	4	22,22	14	77,78	0,70	K3
15.	0	0,00	1	5,56	2	11,11	15	83,33	0,76	
16.	0	0,00	0	0,00	3	16,67	15	83,33	0,78	
17.	0	0,00	0	0,00	2	11,11	16	88,89	0,85	
18.	0	0,00	0	0,00	2	11,11	16	88,89	0,85	

To determine the nature of interpersonal relationships in the women's handball team, we used the conflictometric method developed by I.I. Suleymanov and A.P. Dmitriev. In accordance with the requirements for the implementation of this methodology, we have developed conflictometric selection criteria (questions) for the athletes of the group.

Based on the presented selection criteria, a matrix conflict was compiled (Table 3).

The conflict matrix clearly shows two groups. The first is stable (marked on the conflictogram in different colors, players nos. 8,9,11,13,14,15,16,17 and 18) and is ahead of the second group in terms of level of formation (marked on the conflictogram in yellow, players nos.

1, 2,3,4,5,6,7,10 and 12), since in the first grouping there are ten mutual elections, and in the second there are none.

Table 3 - Conflict matrix

no J I.L.K)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	(+)	(-)	Bcero	
K1			+			+	+												3	0	3	
	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	
	*					*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	
K2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	
				+															3	0	3	
	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	
	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	
																			4	0	4	
	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	4	0	4
	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	
					+													4	0	4		
																		0	0	0		
	-	-			+														4	2	6	
K3				+															4	0	4	
	-				+														4	3	7	
	-		-		-	-													4	4	8	
	-	-	-		-														4	3	7	
	-		-	+		-													4	3	7	
(+)	0	0	1	3	2	2	1	2	5	3	4	0	4	3	3	4	3	2				
(-)	5	2	2	1	1	2	1	0	0	0	0	1	0	0	0	0	0	0				

Based on the conflict matrix, conflictograms were compiled reflecting these two groups and their interpersonal and informal relationships of handball players in the team.

We see a clash between the two factions; where the players of the first group belonged earlier to other teams, and the players of the second group belonged to this team. This is due to the number of negative unidirectional elections by the athletes of the first group to the athletes of the second group.

The second group is undergoing a formation stage between veterans and young people, and at the moment there is no desire to establish new informal ties in it.

In the first grouping, we observe mutual and positive unidirectional elections between its members.

Further, based on the conflict matrix, group (Table 4) and individual (Table 5) conflict metric indices were calculated.

The reciprocity index (RI) for the entire team, reflecting the level of cohesion in the informal sphere of relations, amounted to 0.036 - this is a low indicator. Group Conflict Index (GCI) is the “inverse” reciprocity index. Throughout the group, it is equal to 0, this suggests that the desire of group members to establish informal relations with each other is low.

The reciprocity index in the first grouping was 0.14, and the reciprocity index in the second grouping was 0. The data obtained indicate that the informal cohesion of the first group is three times higher than the general group and significantly higher than the cohesion of the second group.

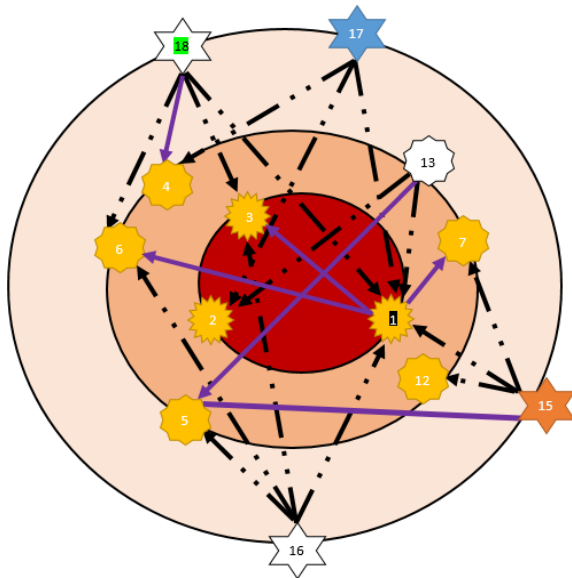


Fig. 1 - Concentric conflictogram informal relationships in the second subgroup

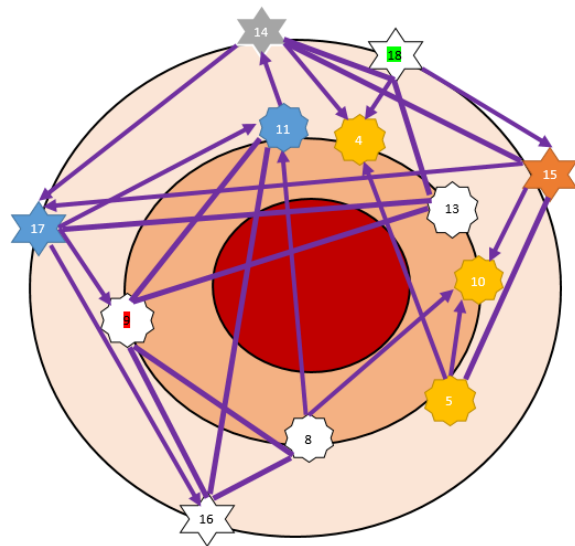


Fig. 2 - Concentric conflictogram of informal relationships in the first subgroup

Table 4 - Group conflict indexes

№	K1			K2									K3					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
IGCE	1			2,1									6,6					3,17
RI	0,14			0,0									0,045					0,036
GCI	0,00			0,00									0,00					0,00

The Group Conflict Expansiveness Index (IGCE) characterizes the desire of group members to establish informal relationships with other group members. The IGCE of the first group was 5.7, and the second group - 0.75. This indicates that the athletes of the first group are more likely to establish informal relations than the second group.

For the group as a whole, the IGCE is 3.17, for the first subgroup it is 1, for the second - 2.1, for the third - 6.6 (subgroups according to the level of individual conflict). These results also show that the most conflicting members of the group, to a lesser extent than less conflicting athletes, tend to establish new informal ties. Such relationships are most important for the third, least conflict subgroup in terms of individual conflict.

Table 5 - Personal Conflict Indexes

№	K1			K2									K3					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
GCS	0,29	0,12	0,18	0,24	0,18	0,24	0,12	0,12	0,29	0,18	0,24	0,06	0,24	0,18	0,18	0,24	0,18	0,12
PCS	0,00	0,00	0,06	0,18	0,12	0,12	0,06	0,12	0,29	0,18	0,24	0,00	0,24	0,18	0,18	0,24	0,18	0,12
NCS	0,29	0,12	0,12	0,06	0,06	0,12	0,06	0,00	0,00	0,00	0,00	0,06	0,00	0,00	0,00	0,00	0,00	0,00
ICE	0,18	0,00	0,00	0,00	0,18	0,00	0,00	0,24	0,24	0,00	0,24	0,00	0,35	0,24	0,41	0,47	0,41	0,41
IPCE	0,18	0,00	0,00	0,00	0,18	0,00	0,00	0,24	0,24	0,00	0,24	0,00	0,24	0,24	0,24	0,24	0,24	0,24
INCE	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,12	0,00	0,18	0,24	0,18	0,18

The Conflict Expansivity Index (ICE), which characterizes the attitude of a group member to its other members, shows that the most conflicted group members, to a lesser extent than less conflicting athletes, tend to establish new informal ties.

The Index of Positive Conflict Expansiveness (IPCE) characterizes the positive attitude of a group member to its other members. He also confirms that athletes in the first group are more likely to support positive informal relationships than athletes in the second group.

You can also notice that the IPCE for all the players in the first subgroup is 0.24, which is higher than the indicator for the second subgroup, equal to 0. Thus, there is a high level of group cohesion in the first subgroup and a low level in the second subgroup.

It should be noted that handball players with low levels of conflict have the highest values of the index of negative conflict expansiveness (INCE). And at the same time, handball players with high levels of conflict have the highest rates of negative conflictometric status (NCS), determined according to the "negative" conflictometric criterion. Therefore, we can talk about the existence of low cohesion in the team.

Positive Conflictometric Status (PCS), which is determined according to the conflictometric criterion with a positive orientation, allows you to identify certain status positions (conflictometric status) of group members: "stars", preferred, accepted, isolated and neglected.

Identified status groups allow you to determine the level of well-being of relationships (LWBR). This concept was introduced by Ya.L. Kolominsky, who proposed identifying three gradations of WBR: high, medium, low.

The 1-st gradation is "stars" (Table 6), the 2nd gradation is "preferred," the 3rd gradation is "accepted," the 4th gradation is "isolated," and the 5 gradation is "neglected."

Table 6 - Conflictometric status of team members

Group name	Number of elections	№ of players
«Stars»	$PKS \geq m + 2\sigma = 0,31$	-
«Preferred»	$PKS > m + 1\sigma = 0,22$	16,13,11,9
«Accepted»	$PKS = m - 1\sigma = 0,052$	18,17,15,14,12,6,5,4,3
«Isolated (Unaccepted)»	$PKS < m - 1\sigma = 0,052$	1,2,12
«Neglected»	$PKS < m - 2\sigma = -0,03$	-

Thus, the number of athletes in the status groups, where the index (PKS) is lower, exceeds the number of athletes in the status groups with a relatively high index.

$$I + II < III + IV + V$$

Therefore, the level of well-being of relationships (BWM) in the team is low.

Conclusions

Conflictometric analysis of interpersonal relationships in a team of highly qualified handball players allows us to state the following:

- the level of group conflict is above average (moderate), which is characterized by the presence of a conflict among individual handball players;
- the average indicator of individual conflict of handball players as a whole is at a level below the average, which indicates a level of conflict below the average;
- the cohesion of the group (according to the indicators of the index of II) - low;
- athletes of the team are divided into two weakly interacting groups, while one of them is dominant, more cohesive;
- athletes of the first group are more likely to establish informal relations than the second group (according to the indicators of the IHEC index);
- the most conflicting members of the group, to a lesser extent than less conflicting athletes, tend to establish new informal ties (according to the indicators of the IKE index);
- athletes of the first group are more inclined to support positive informal relations than athletes in the second group;
- the level of well-being of relationships (BWM) in the team for the study period is low.

The data obtained indicate the need for pedagogical correction of interpersonal relations between athletes and the development of a system of psychological and pedagogical measures to increase group cohesion and prevent the occurrence of acute conflict situations.

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PHYSIOTHERAPY AND REHABILITATION IN PROFESSIONAL SPORTS

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Summary

In professional sports, athletes achieve top results and move their physical and psychological boundaries. Being a professional athlete nowadays requires a lot of discipline, sacrifice, and mental stability. The life and work of a professional athlete are increasingly being disturbed by injuries.

The goal of sports rehabilitation is a fast, targeted and individualized approach when dealing with injuries. Sports rehabilitation unites the athlete and the medical team. The combined efforts of athletes and the entire medical team result in great recovery results in the shortest time possible. The rehabilitation process begins immediately after the injury or surgery, and is divided into several phases. The success and speed of rehabilitation of each injury depend on the personal knowledge and skills of the physical therapist, as well as innovative medical devices.

In sports physiotherapy, it is preferable that the physiotherapist knows and apply specific techniques and concepts of physiotherapy, in addition to expert knowledge in musculoskeletal physiotherapy. In terms of new techniques in physiotherapy rehabilitation, in addition to manual techniques, these techniques are applied as well: Dynamic Neuromuscular Stabilization (DNS), Kaltenborn/Eventh Approach Manual Therapy, McKenzie Concept, Yumeiho Therapy, Myofascial Release (MFR), Emmett Technique, Nerve Neurodynamics (NDS), Proprioceptive Neuromuscular Facilitation (PNF), Instrument Mobilization (IST)) technique, Neurokinetic Therapy (NKT), Dry needling, Medical Flossing, Cupping and others. Nowadays, physiotherapists have at their disposal many new innovative medical devices, besides the classic ones. The new devices include Game Ready or NormaTec recovery systems - cryotherapy, shockwave therapy - shock wave, Interx - interactive stimulation, Tecar therapy, Ergon IASTM Technique, electro-stimulators. Cupping physiotherapy is a branch of medicine that is constantly advancing in professional sport and follows the needs of every top athlete in his work, recovery, and rehabilitation after each injury.

Keywords: physiotherapy, sports rehabilitation, medical therapeutic apparatus, physiotherapy techniques, professional sport

Introduction

In professional sports, athletes achieve excellence and push physical and psychological boundaries (1). Being a professional athlete nowadays requires a lot of discipline, waiver and psychological stability. The life and work of a professional athlete are increasingly aggravated by acute injuries. Injury prevention and rehabilitation - the key to advancing the sport. Every sport, individual or team, has a "Success" goal. What is success? Climb onto the podium, preferably win a gold medal. This is what distinguishes more or less successful individuals or teams. The results achieved depend most on the athlete himself and are followed by a team of experts on their path to success (1). The professional team consists of: a head coach, a coach, a fitness coach, a doctor, a physical therapist, a sports psychologist and a nutritionist. The media that contributes and charts the path to success of every athlete, team, is a big influence.

Prevention

Athletes nowadays have a large selection of prevention measures. In the initial phase, it seems demanding and expensive, but ultimately cost-effective (2). Should team approach towards prevention, the number of acute and chronic injuries would be reduced (1,3). Therefore, the athlete does not step outside the sports field but is goal-oriented, which is "Success". Investigations by Finch and Staines (3) over the course of twenty years of monitoring sports injuries at national level in Australia were conducted to develop guidelines for injury prevention and reduction based on the data obtained. Prevention includes (3): sports systematic examination, fitness training, preparation for training and competition, both physical and psychological (conscious presence and concentration on motor tasks that the athlete should master), regeneration by a physical therapist, nutrition and nutrition supplements, hydration, regeneration clothing, bandages, active orthoses, corsets and rest (daily, weekly, sleep).

Rehabilitation

New advances in sports medicine and rehabilitation are accelerating the recovery of the athlete and his return to the sports field. Rehabilitation follows the protocol for an individual sports injury. New physiotherapy approaches, concepts and new technologically designed medical devices are in use. When sports field injuries occur, proper provision of medical intervention is essential. After a medical examination and, if necessary, specialist treatment, a medical diagnosis is made and early physical rehabilitation is started. Rehabilitation is tailored to the degree of acute injury, surgery, and monitors the individual needs of each athlete and the specificities of each sport.

Assessment instruments: Data were collected using a physiotherapy assessment, and were recorded in a file format that included; subjective information about the athlete, athlete's status, physiotherapy functional diagnosis, and any physiotherapy intervention (SOAP) performed (5) and the Injury and Illness Report (IOC) form. The physiotherapy data collected were recorded in a SOAP format (5) including:

- S: subjective information or information provided by an athlete with her / his current state of health. Pain, swelling etc.
- O: Athlete's status. Conducting clinical tests, measurements and functional specific tests for each type of injury. It measures: range of motion, range of wrist, volume of muscle and joint, endurance and strength of muscle, manual muscle test (MMT) for injured muscle, motivation and attention.
- A: includes a physiotherapy diagnosis (functional diagnosis) that refers to a functional limitation. Goals and outcomes of rehabilitation. Progression due to physiotherapy intervention.
- P: includes physiotherapy interventions performed and procedures that imply the frequency, intensity and duration of each individual physiotherapy intervention and procedure (rehabilitation).

Medical and physiotherapy documentation

Medical records available after specialist examinations are: medical history, medical diagnosis, X-ray (RTG), diagnostic ultrasound (ultrasound), magnetic resonance imaging (MR), scintigraphy and computer tomography (CT).

Discussion

In Canada (4,6) and Australia (3), electronic "data banks" have been designed to allow the entry and collection of unique information on athletes from various sources in a simple and systematic manner and to systematically track athletes' sports injuries. Data and information are collected on the general health of the athletes, their acute and chronic injuries, and systematic monitoring of the performed medical intervention, surgery and rehabilitation enables the development of rehabilitation protocols for each injury and the development of new strategies for the implementation of prevention (3,4,6,7).

Drew and associates. (1) state in a 2017 survey that injuries adversely affect the success of teams as in individual sports, and injuries suffered before and during competition may increase the risk of failure. (1) Injury prevention should therefore be a priority for maximizing sports performance. Health professionals; The team doctor, physical therapist and fitness coach face the challenge of returning the athlete to the competition as quickly and safely as possible. There is often a conflict of interest between the team physician and the athlete and other members of the sports organization, including coaches, team management and sponsors (8).

In sports physiotherapy, in addition to expertise in musculoskeletal physiotherapy, physiotherapist applies specific techniques and concepts to physiotherapy. Of the new techniques in physiotherapy rehabilitation are applied in addition to manual techniques; Dynamic Neuromuscular Stabilization (DNS), Kaltenborn / Evening Approach Manual Therapy, McKenzie Concept, Myofascial Release (MFR) (9), Nerve Neurodynamics (NDS), Proprioceptive Neuromuscular Facilitation (PNF) (10), Instrument assisted soft tissue mobilization (IA)) technique, Neurokinetic therapy (NKT), Dry needling, Medical Flossing, Emmett technique (11), Cupping (12), Yumeiho (13) therapy and many others.

Dynamic Neuromuscular Stabilization (DNS) is a functional method in rehabilitation and prevention that aims to activate the body's natural stabilization system through the principles of motor development. It activates an inherent stabilization system for the restoration of innate neuromuscular pathways, which have been lost over the years. Through the restoration of these pathways, trainees regain their proper and painless biomechanical functions (14). Instrument Assisted Soft Tissue Mobilization (IASTM) (15,16) technique in musculoskeletal physiotherapy relaxes muscles, ligaments and fascia using metal instruments. While Neurokinetic Therapy (NKT) (17) is a form of manual therapy that combines motor control theory and manual muscle testing to find the cause of a pain-dysfunctional movement pattern stored in the brain. The Dry needling (18) therapeutic procedure uses needles to relax painful and tense muscles. Medical Flossing (19) is a therapeutic method that uses a latex rubber band that acts on the surface of the skin with high cohesive force and has an effect on blood flow to muscle tissue and reduces pain. Kaltenborn / Evjenth manual physiotherapy is a specialist part of musculoskeletal physiotherapy consisting of differential and specific examination and therapy of joints, muscles and peripheral nerves (13).

Nowadays, physiotherapists have at their disposal, in addition to classic medical devices, a number of new innovative ones. Of the new ones, the Gemredy or NormaTec Recovery System - which is used for regeneration, recovery and cryotherapy (20) - is being applied.

Shockwave Therapy - Shock Wave (21), Interx - Interactive Stimulation (22), Tecar Therapy (23), Ergon Iastm (24), Electrostimulators. Physiotherapy is a branch of medicine that in the top sport is constantly advancing and follows the needs of every top athlete in his work, recovery and rehabilitation after each individual injury (5,7). It is recommended by Ross (6) for further research to go in the direction of monitoring the course and type of rehabilitation in both national selections and sports clubs.

Conclusion

Injury prevention and rehabilitation are the keys to advances in sports. Physiotherapy is a branch of medicine that in the top sport is constantly advancing and follows the needs of every top athlete in his work, recovery and rehabilitation after every single injury. Recommendation for further research in medicine and physiotherapy to move towards prevention in order to reduce the number of acute and chronic injuries in top sport. In sports, there is a need to develop strategies that would be geared toward years of prevention and education of professional staff who would implement them in their work with athletes.

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THE MOST COMMON INJURIES IN TEAM SPORTS AND THEIR EARLY REHABILITATION WITH THE USE OF ORTHOPEDIC SPORT SUPPORTS

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Summary

Team sports, such as handball, basketball, volleyball, football, all contain numerous changes of direction, jumps, landings in which acute traumatic injuries are frequent. The most common injuries are ankle distortion and dislocation, with the younger age groups and female athletes at risk. With the senior population, acute knee ligament injuries are common; anterior cruciate ligament (lat. ligamentum cruciatum anterius - ACL), posterior cruciate ligament (lat. posterior cruciatum ligament - PCL), medial collateral ligament (lat. medial colletaral ligament - MCL). The cause of acute injuries may be trauma, resulting from the athlete's contact with a teammate during competition and training, contact with the base, contact with the ball, fence or on-field advertising. When sports field injuries occur, proper decision-making in a short period of time and providing physiotherapy intervention is essential. In the first phase, the protocol, containing protection, rest, ice, compression and elevation (PRICE), is respected. After a medical examination and specialist's treatment, a doctor gives the diagnosis and continues to an early sports physical therapy rehabilitation. In the second phase, the rehabilitation is adjusted to the degree of the strain, partial or complete rupture of the ligament system, and addresses the individual needs of the athlete. The new advances in the domain of sports medicine and rehabilitation accelerate the recovery of the athlete and his/her return to the sports field. During the gradual return of an athlete to the field, in addition to the physiotherapy treatments, physical therapies and exercise programs, bandages, active orthoses and braces are also given. The orthopedic supplies used for injuries in team sports are: sports ankle and elbow support, sports wrist strap, dynamic sport ankle support and sport support for the knee. They are used in the rehabilitation phase, recovery, training and sports activities, and can be used in the prevention of the occurrence of injuries. Their benefit is that they increase endurance and enable faster recovery, and do not interfere with the biomechanics of joint movement.

Keywords: team sport, acute sports injuries, physiotherapy, sport rehabilitation, orthopedic sports orthoses

Introduction

Team sports; Handball, basketball, volleyball, football all contain numerous changes of direction, jumps, jumps in which acute traumatic injuries are frequent.

Handball is a team Olympic sport that requires an athlete's mental and high level of physical and tactical competence (31,19). All athletes who are conditionally unprepared and tactically ill-prepared are at increased risk of sports injuries, illnesses and chronic injuries (5,8).

Sports injuries interfere the athletic success on individuals level and team (4) and impose a financial burden on the public health program (11). Therefore, injury prevention is of great importance (30). Injury is any tissue damage incurred within a specified and limited time (8).

The term sports injury in the broad sense includes all injuries that have occurred during any kinesiological activity. Sports injury in the narrow sense indicates an injury typical of a particular sport branch, according to its mechanism of occurrence and frequency (8).

In football, basketball and handball, acute sports injury is defined as any physical injury caused by a player himself during a training or match (12).

Injuries are common in sports, which is why an integral part of any national selection, sports team, is the physician and physiotherapist who take care of the health of the athlete.

The aim of this review work is to attempt to present relevant literature that confirms the hypothesis of an association between the incidence of acute injuries in professional sports, handball and handball. Prevention and rehabilitation using bandages and orthopedic sports aids.

Methods

A review of the literature and scientific papers was conducted through the following databases: PubMed, Sports Health, Health and Sport, SpringerLink, Google Scholar as of September 1, 2019. The papers were cited by reference, and included those aimed at reviewing the most common injuries in team sports, with an emphasis on handball.

And the application of medical intervention and prevention in sports injuries. The databases were searched using keywords from several categories according to the PICO acronym (Population, Intervention, Control, Outcome).

Results and Discussion

A group of authors Olsen et al. (15,16) conducted injury incidence studies on seven sports in Sweden between 2006 and 2013. and they state that handball is second in number to acute injuries.

Handball injuries are the result of contact when attacking or defending (13). The most common injuries to athletes are due to frequent changes of the handgrip surfaces, which are inflammation of the Achilles tendons and inflammation of the periosteum (16).

In handball, during match and training, athletes use glue to play, that is, to catch and add a handball, which contributes to the formation of injured fingers and the movement of the small bones of the fingers (13).

Studies conducted by German authors (9,12,17) state that the most common acute injuries of sprains and contusions are in the female and male population in the age range 14-45 years playing active handball in Germany. Their ratio is two injuries per 1000 (working) hours of coaching or playing. It is important to emphasize that the injuries of the lower extremities with no contact are more frequent in the handball players, with the knee with 32% and the ankle with 22%, with the handball players having a higher proportion of injuries during contact and depending on the position they play.

The results of the systematic monitoring of athletes' injuries by play position and mode of movement (whether on offense or defense) indicate that athletes are more exposed to injuries at the position of line circular, left, middle and right outside in attack. Players on the attack are more exposed to acute sports injuries (11,17).

The origin and type of injury is also influenced by the type of substrate. Olsen and associates (16) stated that the greater number of injuries to the anterior cruciate ligament (ACL) of the knee was in artificial handball players than in handball players. According to them, all artificial substrates have a higher friction than the parquet floor and thus increase the risk of injuries to the knee and ankle of the handball players. Acute knee injuries in artificial athletes often occurred without contact with a rival player (16). Frequent changes to the surfaces on which handball is practiced and played lead to overuse injuries (16), sore inflammation and chronic inflammation.

Girot and associates . (6) conducted a study in the Brazilian Championships within two world championships and found that the occurrence of an overuse injury, tendinopathy (92%,) was affected by a previous injury. Unlike the older age, Olsen and associates (15) stated that young athletes in Scandinavia are more prone to injuries and fractures of the fingers, wrists and forearms.

They have found that the percentage of injuries in handball is increasing for younger ages who play higher level handball while referring to the European Championship (EP) and the World Cup (SP). The International Handball Federation (IHF) held the World Senior Handball Federation (IHF) during the 24th World Senior Handball Championship from 15 January to 1 February 2015. authorized the authors (3) to collect and systematize data on acute injuries and diseases using the Injury and Disease Control Protocol (IOC).

It has been estimated that there is the highest risk of injury among players on the pivot line and a greater number of acute sports injuries during the first half of the game. The most common injuries are the ankle, thighs, knees, head and face, such as contusions, stretching, and overuse injuries (3).

Studies that have included monitoring handball players (9,11,12,14,15,16) have shown that the most common injuries are lower limb injuries. Luig and the authors in a study (13) conducted in Germany report that women with hand injuries are the leading injuries to the lower extremities of sprains and contusions. Studies (3,13,14,17), through systematization of data and statistical analysis, have concluded that injuries are more likely for handball players in the position of pivot, left, middle and right external.

In a study conducted in Norway and the Czech Republic over a period of five years, Henke and associates (9) stated that 10 times the number of injuries occurred during matches involving the lower extremities, head and upper extremity injuries, while Olsen and associates (16) In a study conducted in Scandinavia, findings were reported on the number of injuries to the fingers, wrists and forearms in national selections.

When sports field injuries occur, proper decision making in the short term and providing physiotherapy intervention is essential (10). In the first phase, the protocol: protection, rest, ice, compression and elevation (PRICE) (10) are respected. The physiotherapist collects subjective information from the athlete, conducts a physiotherapy assessment consisting of clinical and specific physiotherapy tests for physiotherapy diagnosis, and in consultation with the physician, sends the athlete for medical diagnostic treatment to a specialized hospital facility. After a medical examination and specialist treatment, a doctor is diagnosed and moves into early sports physical therapy rehabilitation. In the second stage, the rehabilitation is adapted to the degree of stretching, partial or complete rupture of the ligament system and follows the individual needs of the individual athlete (18,19,20,21).

New advances in sports medicine and rehabilitation are accelerating the recovery of the athlete and his return to the sports field (7). In the gradual return of athletes to the field, in addition to physiotherapy treatments, physical therapies and exercise programs (18,21), bandages, active orthoses and clamps (1) are applied. From the orthopedic line for injuries in team sports, the following applies: sports ankle support, dynamic ankle support and knee support (2). They are used in the rehabilitation phase, recovery, training and sports activities, and can be used in the prevention of injuries. Their benefit is that they increase endurance and enable faster recovery, and do not interfere with the biomechanics of movement in the joint.

Conclusion

In team sports, and especially in handball, athletes are exposed to daily acute injuries. From an ethical, health point of view, athlete health comes first. In order to reduce the percentage of injuries, it is essential to work with athletes systematically and on a planned basis during prevention as well as during the competition. Daily records and systematization of the work of physicians, physical therapists, fitness coaches provide accurate and accurate information on individual sports injuries, performed physical therapy interventions, rehabilitation protocols, and the time and duration of individual rehabilitation exercise programs, individual therapies and overall rehabilitation. Based on the data obtained, physiotherapy protocols and programs for the rehabilitation of acute sports injuries can be developed and supplemented.

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DEVELOPMENT OF STATISTICAL DATA INDEX FOR EVALUATING THE TACTICAL ASPECTS OF ATTACK AND DEFENSE IN HANDBALL

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Summary

The purpose of this study was to develop the useful statistical data indexes to evaluate the team performance of attack and defense during handball match. The subject of analysis in this study were 216 matches of Japan Handball League in 2017-2018 and 2018-2019 seasons and 145 matches of Handball-Bundesliga in 2018-2019 season. We calculated the ratio of goal, free throw, turnover against the possessions to make an index of expected goal (xG), expected received free throw (xRTF) and expected turnover (xTO) in attack phase. Similar, expected opposing goal (xL), expected taken free throw (xTTF) and expected opposing turnover (OppxTO) were calculated in defense phase. Also, shot efficiency (%G) and opposing shot efficiency (%L) were calculated. As a results of multiple regression analysis, we found that %G, xTO and xRTF in attack phase and %L, OppxTO and xTTF in defense phase were important variables to evaluate the team performance. In conclusion, %G, xRTF and xTO in the attack phase and %L, xTTF and OppxTO in the defense phase are important indexes for evaluating the team performance and these are very useful statistical indexes for real-time analysis during the match.

Keyword: quantitative analysis, quality analysis

Introduction

Match analysis of sports can help coach decisions and improve team performance. It is very important to use reliable performance indicators for match analysis. In previous study, we calculated the ratio (xG) of number of goal scores against the number of possessions as an attack index and the ratio (xL) of number of opposing goal scores against the number of opposing possessions as a defense index (Ichimura et al. 2017). The required values of the xG and xL to qualify the preliminary round in men's world handball competitions was calculated using ROC curve analysis. Therefore, we believe that xG and xL are very powerful indexes for evaluating the team performance of attack and defense. However, xG and xL cannot clarify the details of their team performance because xG and xL include all attacking and defense information such as turnover and shot efficiency.

Thus, we have to search the more detailed indexes to evaluate the more detailed team performance. Thus, the purpose of this study was to develop the useful statistical data indexes to evaluate the team performance of attack and defense during handball match, based on terminate of attack or defense phase.

Methods

Data collection

The subject of analysis in this study were all matches (216 matches) of Japan Handball League (JHL) in two seasons of 2017-2018 and 2018-2019 and 145 matches of all matches (306 matches) of Handball-Bundesliga (HBL) in 2018-2019 season.

The flowchart of how to terminate of attack was shown in figure 1. Based on figure 1, the we counted “Possession”, “Shot”, “Goal”, “Assist play”, “Turnover”, “Free throw”, “2 minutes suspension” during attack phase on each team.

And, in this study, we made the attack and defense indexes based on terminate of attack or defense. Using these variables, we calculated the ratio of shot, goal, assist play, free throw, turnover and 2 minutes suspension against the possessions to make an index of expected shooting play (xS), expected goal (xG), expected received free throw (xRTF), expected turnover (xTO), expected taken 2minutes suspension (x2M) during attack phase. And shot efficiency (%G) and assist efficiency (%AST) also was calculated. Similarly, we made the defending index during opposing possession. Expected opposing shooting play (OppxS), expected opposing goal (xL), expected turn over (OppxTO), expected free throw (xTTF), expected 2minutes suspension (Opp x2M) were calculated during attack phase. And opposing shot efficiency (%L) and opposing assist efficiency (Opp%AST) also was calculated.

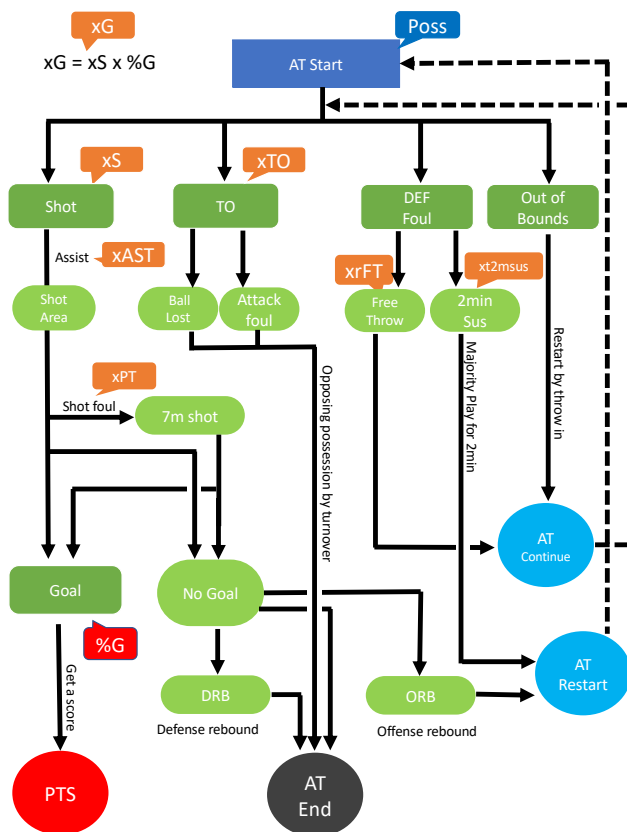


Figure 1 The flowchart of how to terminate of attack phase

index into 5 levels of “Excellent”, “Good”, “Average”, “Poor” and “Terrible” using 68-95-99.7 rules from data of average and standard deviation to evaluate the team performance.

expected turn over (OppxTO), expected free throw (xTTF), expected 2minutes suspension (Opp x2M) were calculated during attack phase. And opposing shot efficiency (%L) and opposing assist efficiency (Opp%AST) also was calculated.

Data analysis

In order to confirm whether or not the created indexes are a useful index, a multiple regression analysis was performed using the xRFT, xTO, x7M, %G and %AST as an explanatory variable and goal score as an objective variable. Similarly, multiple regression analysis was performed for the defense index (opposing goal score, xTFT, OppxTO, Oppx7M, %L and Opp%AST).

We categorized using cluster analysis using selected variables to determine whether the indexes selected by multiple regression analysis affect team performance in each national league. We also classified the attack and defense

Results & Discussion

Indexes of attack and defense phases

Table 1 was shown the average value of indexes of attack and defense for each team in JHL and table 2 was shown these in HBL. In JHL, there were significant differences in the values of xG and %G of attack indexes and xL and %L of defense indexes between the upper team and the bottom team in the final ranking. In HBL, the values of xG and %G was significant larger in upper team than in bottom team in the final ranking. In defense, SG the value of xL of Flensburg-Handewitt was smaller than that of bottom teams but there was not differences in the value of %L among teams.

In each league, required xG and xL for the final ranking to become the top 4 teams were analyzed using ROC analysis. In the JHL, required value of xG was greater than or equal to 0.466 and that of xL was less than or equal to 0.476. In HBL, required value of xG was greater than or equal to 0.545 and that of xL was less than or equal to 0.508.

Table1 Attack and defense parameter of Japan Handball League in 2017-2018 and 2018-2019											
Attack											
Team	n	Rank	Cluster	N of Attacks	N of Goals	xG	%G	xTO	xRFT	x7m	%AST
Osaki Electric	48	1	1	57.9±4.8	28.2±5.4	0.487±0.084*, #, \$	0.595±0.088*, #, \$	0.183±0.054	0.133±0.073	0.035±0.026	0.506±0.194
Toyoda Gosei	48	2	1	59.8±4.2	29±4.1	0.485±0.065*, #, \$	0.599±0.081*, #, \$	0.189±0.042	0.134±0.101	0.042±0.028	0.51±0.195
Toyota Auto Body	48	3	1	58.5±4.6	29.1±4.4	0.498±0.07*, #, \$	0.619±0.074*, #, \$	0.198±0.062	0.135±0.091	0.031±0.024	0.475±0.198
Daido Steel	48	4	2	56.9±4.2	26.6±3.5	0.468±0.059*, \$	0.567±0.063*, #, \$	0.176±0.05	0.142±0.074	0.046±0.03	0.509±0.179
Toyota Boshoku Kyushu	48	5	2	59.9±4.3	27.1±3.3	0.456±0.064*, #	0.562±0.075*, #	0.192±0.059	0.155±0.109	0.046±0.027	0.47±0.193
Wakunaga Pharmaceutical	48	6	4	57±4.8	23.8±3.6	0.418±0.061	0.528±0.075	0.206±0.051	0.164±0.105	0.033±0.025	0.491±0.165
Toyota Motor East Japan	48	7	3	55.8±4.5	24.2±3.7	0.434±0.057*	0.538±0.068	0.192±0.054	0.134±0.101	0.03±0.025	0.482±0.214
Hokuriku Electric Power	48	8	3	59.7±4.2	24.1±4.1	0.404±0.066	0.504±0.088	0.194±0.051	0.135±0.09	0.029±0.023	0.455±0.21
Ryukyu Corazon	48	9	4	58.7±4.7	22.1±3.6	0.378±0.067	0.474±0.077	0.206±0.068	0.157±0.094	0.036±0.026	0.435±0.224
Defense											
Team	n	Rank	Cluster	N of Defenses	Lost Goal	xL	%L	OppxTO	xTFT	Oppx7m	%OppAST
Osaki Electric	48	1	1	57.9±5.4	23.5±3.4	0.407±0.054*, #, \$	0.522±0.066*, #, \$	0.219±0.054	0.129±0.077	0.036±0.028	0.473±0.195
Toyoda Gosei	48	2	3	59.9±3.7	26±4.2	0.435±0.068*, #, \$	0.56±0.077*, #, \$	0.224±0.054	0.144±0.077	0.038±0.027	0.509±0.2
Toyota Auto Body	48	3	1	60±4.2	24.5±3.9	0.41±0.069*, #, & \$	0.509±0.079*, #, \$	0.198±0.045	0.124±0.085	0.046±0.029	0.512±0.202
Daido Steel	48	4	2	57.3±4.7	24.7±4.1	0.433±0.079*, #, \$	0.539±0.091*, #, \$	0.197±0.052	0.152±0.079	0.031±0.021	0.537±0.208
Toyota Boshoku Kyushu	48	5	3	59.8±4.3	28.9±4.9	0.483±0.071*, #	0.571±0.083	0.156±0.05	0.163±0.114	0.029±0.025	0.418±0.152
Wakunaga Pharmaceutical	48	6	2	57.6±3.9	25.4±4.9	0.441±0.08	0.531±0.095	0.168±0.047	0.138±0.084	0.041±0.024	0.527±0.215
Toyota Motor East Japan	48	7	3	55.6±5.2	25.9±4.3	0.466±0.071	0.572±0.086	0.183±0.058	0.179±0.118	0.035±0.026	0.421±0.208
Hokuriku Electric Power	48	8	4	58.7±3.6	29.6±4.7	0.505±0.078	0.619±0.084	0.184±0.054	0.12±0.076	0.037±0.027	0.445±0.172
Ryukyu Corazon	48	9	4	57.1±4.7	26.5±4.1	0.464±0.061	0.585±0.082	0.203±0.051	0.141±0.112	0.035±0.028	0.485±0.188

* vs Ryukyu Corazon, p<0.01, # vs Hokuriku Electric Power, p<0.01, \$ vs Wakunaga Pharmaceutical, p<0.01

Attack											
Team	n	Rank	Cluster	N of Attacks	N of Goals	xG	%G	xTO	xRFT	x7m	%AST
SG Flensburg-Handewitt	22	1	1	50 ± 7	27.2 ± 4.9	0.547 ± 0.077*	0.639 ± 0.084	0.145 ± 0.04	0.184 ± 0.115	0.077 ± 0.037	0.472 ± 0.177
THW Kiel	14	2	1	51.8 ± 4	27.9 ± 4.4	0.54 ± 0.077*	0.631 ± 0.098	0.142 ± 0.032	0.232 ± 0.093	0.08 ± 0.039	0.452 ± 0.167
SC Magdeburg	17	3	1	53.2 ± 4.1	29.7 ± 4.3	0.557 ± 0.059*	0.661 ± 0.066*	0.157 ± 0.039	0.172 ± 0.101	0.094 ± 0.054	0.482 ± 0.213
Rhein-Neckar Löwen	14	4	1	50.6 ± 11.9	26.3 ± 6.6	0.53 ± 0.079	0.607 ± 0.094	0.124 ± 0.044	0.201 ± 0.161	0.056 ± 0.032	0.509 ± 0.165
MT Melsungen	13	5	2	52.8 ± 3.1	27.6 ± 4.3	0.525 ± 0.086	0.617 ± 0.086	0.151 ± 0.044	0.248 ± 0.164	0.07 ± 0.028	0.529 ± 0.227
Füchse Berlin	17	6	2	51.1 ± 5.2	26.9 ± 3.7	0.528 ± 0.063	0.644 ± 0.079	0.179 ± 0.04	0.288 ± 0.12	0.098 ± 0.033	0.61 ± 0.138
Bergischer HC	14	7	3	52.1 ± 3.5	26 ± 3.6	0.502 ± 0.08	0.588 ± 0.101	0.144 ± 0.041	0.211 ± 0.112	0.073 ± 0.044	0.539 ± 0.218
FRISCH AUF! Göttingen	15	8	3	51.6 ± 4	25.8 ± 4.8	0.5 ± 0.087	0.596 ± 0.105	0.16 ± 0.037	0.238 ± 0.105	0.083 ± 0.031	0.564 ± 0.208
HC Erlangen	21	9	2	50.2 ± 4.9	24.9 ± 2.7	0.5 ± 0.076	0.609 ± 0.087	0.177 ± 0.059	0.315 ± 0.129	0.075 ± 0.047	0.477 ± 0.14
HSG Wetzlar	15	10	2	49.3 ± 3.3	26.4 ± 3.5	0.537 ± 0.079	0.629 ± 0.077	0.147 ± 0.045	0.324 ± 0.131	0.086 ± 0.028	0.515 ± 0.137
SC DHfK Leipzig	15	11	2	50.5 ± 4	25.9 ± 4.1	0.515 ± 0.077	0.611 ± 0.077	0.158 ± 0.061	0.298 ± 0.141	0.057 ± 0.034	0.441 ± 0.111
TBV Lemgo Lippe	15	12	2	51.5 ± 3.8	25.1 ± 3.4	0.487 ± 0.048	0.589 ± 0.048	0.171 ± 0.061	0.337 ± 0.12	0.079 ± 0.052	0.525 ± 0.158
TSV Hannover-Burgdorf	22	13	1	50.7 ± 6.5	27.1 ± 4	0.537 ± 0.063*	0.628 ± 0.063	0.146 ± 0.048	0.21 ± 0.11	0.081 ± 0.037	0.531 ± 0.167
TSV GWD Minden	22	14	3	55.2 ± 4.6	27.5 ± 3.8	0.499 ± 0.058	0.596 ± 0.082	0.159 ± 0.049	0.204 ± 0.1	0.059 ± 0.033	0.47 ± 0.119
TVB 1898 Stuttgart	13	15	3	57.5 ± 3	27.8 ± 4.3	0.484 ± 0.072	0.586 ± 0.07	0.175 ± 0.063	0.185 ± 0.081	0.063 ± 0.038	0.355 ± 0.125
Die Eulen Ludwigshafen	19	16	4	49.8 ± 4.4	23 ± 3	0.464 ± 0.063	0.567 ± 0.068	0.182 ± 0.05	0.397 ± 0.17	0.063 ± 0.03	0.45 ± 0.195
VfL Gummersbach	13	17	3	52.2 ± 4.9	25.5 ± 3.6	0.488 ± 0.057	0.574 ± 0.065	0.149 ± 0.059	0.253 ± 0.132	0.052 ± 0.033	0.464 ± 0.196
SG BBM Bietigheim	9	18	4	48 ± 14.6	23 ± 8	0.451 ± 0.119	0.549 ± 0.139	0.184 ± 0.049	0.332 ± 0.151	0.066 ± 0.037	0.423 ± 0.173
Defense											
Team	n	Rank	Cluster	N of Defenses	Lost Goal	xL	%L	OppxTO	xTFT	Oppx7m	%OppAST
SG Flensburg-Handewitt	22	1	1	51.4 ± 7	22.4 ± 4	0.442 ± 0.081	0.528 ± 0.077	0.166 ± 0.051	0.288 ± 0.174	0.074 ± 0.044	0.486 ± 0.155
THW Kiel	14	2	1	52.2 ± 4.2	24.8 ± 4.3	0.474 ± 0.07	0.585 ± 0.083	0.187 ± 0.064	0.303 ± 0.159	0.051 ± 0.032	0.443 ± 0.211
SC Magdeburg	17	3	1	54.7 ± 4.4	25.8 ± 3.7	0.473 ± 0.063	0.583 ± 0.074	0.188 ± 0.049	0.225 ± 0.114	0.071 ± 0.03	0.517 ± 0.203
Rhein-Neckar Löwen	14	4	1	48.7 ± 12.2	23.9 ± 6.9	0.471 ± 0.105	0.561 ± 0.118	0.165 ± 0.055	0.248 ± 0.188	0.062 ± 0.044	0.37 ± 0.168
MT Melsungen	13	5	2	53.8 ± 3.4	26.1 ± 3.4	0.487 ± 0.068	0.56 ± 0.074	0.132 ± 0.04	0.238 ± 0.133	0.082 ± 0.053	0.49 ± 0.16
Füchse Berlin	17	6	3	50.5 ± 4	27.3 ± 4.5	0.54 ± 0.072#	0.63 ± 0.077	0.143 ± 0.048	0.223 ± 0.109	0.076 ± 0.047	0.571 ± 0.154
Bergischer HC	14	7	4	51.1 ± 2.7	25.6 ± 2.8	0.503 ± 0.056	0.607 ± 0.086	0.168 ± 0.052	0.259 ± 0.085	0.062 ± 0.037	0.395 ± 0.123
FRISCH AUF! Göttingen	15	8	2	53.4 ± 3.5	25.9 ± 2.9	0.486 ± 0.054	0.57 ± 0.058	0.148 ± 0.046	0.17 ± 0.048	0.077 ± 0.035	0.604 ± 0.186
HC Erlangen	21	9	4	48.2 ± 3.5	25.5 ± 1.8	0.531 ± 0.04#	0.638 ± 0.055	0.166 ± 0.036	0.333 ± 0.161	0.081 ± 0.055	0.524 ± 0.142
HSG Wetzlar	15	10	4	50.5 ± 4.8	26.5 ± 4.6	0.523 ± 0.07	0.604 ± 0.081	0.133 ± 0.047	0.347 ± 0.14	0.067 ± 0.037	0.476 ± 0.195
SC DHfK Leipzig	15	11	1	49.7 ± 2.9	25.4 ± 2	0.512 ± 0.048	0.627 ± 0.067	0.182 ± 0.041	0.279 ± 0.148	0.073 ± 0.03	0.526 ± 0.138
TBV Lemgo Lippe	15	12	3	51.2 ± 3.7	27.4 ± 4.5	0.538 ± 0.098#	0.626 ± 0.109	0.14 ± 0.041	0.209 ± 0.099	0.068 ± 0.038	0.544 ± 0.138
TSV Hannover-Burgdorf	22	13	4	51.4 ± 6.7	27.8 ± 4.4	0.544 ± 0.069#	0.643 ± 0.069	0.154 ± 0.059	0.256 ± 0.121	0.082 ± 0.036	0.438 ± 0.138
TSV GWD Minden	22	14	4	54.9 ± 3.5	28.3 ± 4.3	0.517 ± 0.076	0.616 ± 0.078	0.163 ± 0.042	0.23 ± 0.113	0.072 ± 0.031	0.495 ± 0.135
TVB 1898 Stuttgart	13	15	3	57.4 ± 4.3	32.2 ± 3.1	0.562 ± 0.043#	0.666 ± 0.061	0.153 ± 0.051	0.164 ± 0.113	0.068 ± 0.029	0.476 ± 0.207
Die Eulen Ludwigshafen	19	16	3	49.3 ± 4	27.4 ± 3.4	0.557 ± 0.066#	0.652 ± 0.056	0.147 ± 0.039	0.224 ± 0.104	0.091 ± 0.034	0.552 ± 0.176
VfL Gummersbach	13	17	4	51.9 ± 5.3	27.6 ± 4.1	0.533 ± 0.069#	0.626 ± 0.084	0.147 ± 0.044	0.26 ± 0.148	0.083 ± 0.03	0.468 ± 0.231
SG BBM Bietigheim	9	18	4	47.8 ± 13.9	24.9 ± 6.6	0.538 ± 0.079#	0.638 ± 0.098	0.153 ± 0.059	0.296 ± 0.169	0.067 ± 0.041	0.497 ± 0.23

* vs Die Eulen Ludwigshafen, p<0.01, # vs SG Flensburg-Handewitt, p<0.01

These xG or xL indicate the ratio of the number of goal scores or opposing goal scores against number of attacking or defense possessions, and are very powerful indexes for evaluating team performance. However, xG and xL cannot clarify the details of their team performance because xG and xL include all attacking and defense information such as turnover and shot success rate. Thus, we have to search the more detailed indexes to evaluate the more detailed team performance.

Search for useful attack and defense indexes for real time-match analysis

As a result of correlation analysis between the attack index and the defensive index, very high correlation coefficient was observed between xG and %G and between xS and xTO. From the these results, these variables were considered to have multicollinearity. Thus, xG and xS were excluded from the variables for multiple regression analysis. In this study, we performed the multiple regression analysis to search the useful attack and defense indexes for real-time match analysis.

standardized partial regression coefficient		
	JHL	HBL
%G	0.845*	0.642*
xTO	-0.336*	-0.277*
xRFT	-0.134*	-0.299*
x7m	-0.024	-0.066
%AST	-0.051	-0.013

	JHL			HBL		
	%G	xTO	xRFT	%G	xTO	xRFT
Great	0.732	0.082	0.000	0.772	0.059	0.000
Good	0.644	0.137	0.050	0.691	0.108	0.118
Average	0.555	0.193	0.143	0.610	0.158	0.251
Poor	0.467	0.248	0.236	0.530	0.207	0.384
Terrible	0.378	0.303	0.329	0.449	0.256	0.516

As a results of multiple regression analysis with attack indexes as an explanatory variables and goal score as an objective variable, the multiple regression coefficient were 0.814 and 0.617 in attack indexes in JHL and HBL, respectively. These results were statistically significant value ($p < 0.01$). The standardized partial regression coefficient from each explanatory variable to the objective variable were as shown in Table 3. This result was shown that the influence on the goal score were in the order of %G, xTO, xRFT in attack phase. The results in defense phase were also similar. Therefore, we made the prediction formula as follows;

JHL

$$\text{Goal} = 44.889 \times (\%G) - 28.306 \times (xTO) - 5.941 \times (xRFT) + 7.462$$

HBL

$$\text{Goal} = 33.571 \times (\%G) - 24.467 \times (xTO) - 9.677 \times (xRFT) + 12.248$$

These formula also demonstrated that the impact of each index on the goal or opposing goal score. We found that %G has positive effect and xTO and xRFT has negative effect on the goal scores in attack phase. Thus, a high shooting efficiency led to high goal scores and the turnovers by offense ball lost, offense fouls, and/or intercepts led to be lower the goal scores. Interestingly, stopped the attack by a minor foul of an opponent defense player caused a low goal score. Thus, it is possible to perform simple and sufficient match analysis by counting the number of possessions, goals, turnovers, and free throws at each team's attack.

These three indexes for attack and defense are included in xG and xL, respectively (Figure 1). In other words, xG demonstrates the ability of the whole attack, %G demonstrates the goal ability, xTO demonstrates the ability to finish the attack with a shooting play, and xRFT demonstrates the ability to be able to continue the attacking behavior without being obstructed by the opposing defense. In defense, xL demonstrates the ability of the whole defense, %L demonstrates the to prevent the opposing goal ability, OppxTO demonstrates the ability to be finished the attack without a shooting play against opposing offense, and xTTF demonstrates the ability to be able to stop the attacking behavior by the defender.

Table 5 The value of 3 indexes at match of TSV Hannover-Burgdorf vs Fuchse Berlin on 13th Sep in 2018

	Goals	Possession	xG	%G	xTO	xRTF
TSV Hannover-Burgdorf	28	49	0.571	0.683	0.163	0.061
Fuchse Berlin	29	54	0.537	0.691	0.222	0.130

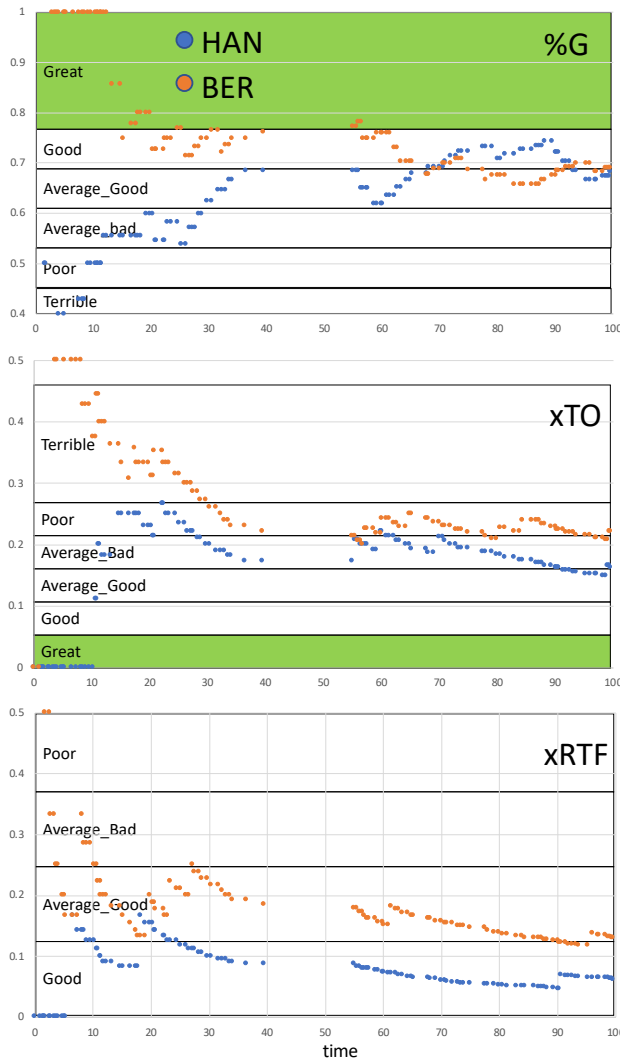


Figure 2 dynamic analysis of xTO, xRTF and %G

and the attack could terminate by a shooting play, compared to BER. However, the shot efficiency of HAN was lower than that of BER although shot efficiency was high level in both of team. Thus, the shot efficiency of BER was superior in this match. This superior shot efficiency of BER is considered to be a factor to win in this match. In addition, it is thought that an acquisition of the offense rebound greatly affected the outcome of this match because the number of possessions in BER was five times higher than HAN.

In addition, we can easily understand the status of the team performance on the own team and the opponent team during the match in real-time by using these indexes. For example, figure 2 was shown the results of dynamic analysis of each index data.

Match analysis using variables selected in multiple regression analysis

We performed cluster analysis in each league using useful indexes calculated by multiple regression analysis in attack and defense phase to clarify team performance. In JHL and HBL, each team could be classified into 4 clusters in both of attack and defense phases (Table 1, Table 2). From this result, the team's performance can be objectively evaluated not only by the match outcome but also by the performance of both attack and defense.

We also classified the useful indexes of attack and defense phase into 5 levels (Excellent, Good, Average, Poor, Terrible) using 68-95-99.7 rules from data of average and standard deviation to evaluate the team abilities. Table 4 was shown the results of classifying the value of %G, xTO and xRFT in attack phase and that of %L, OppxTO and xTFT in defense phase into 5 levels. We can perform not only the static match analysis but also the dynamic analysis (real-time match analysis) using this method. Table 5 was shown the results of the September 13th 2018 match between TSV Hannover-Burgdorf (HAN) and Fuchse Berlin (BER). The value of xRTF was “good” in HAN, “average-good” in BER, that of xTO was “average-poor” in HAN, “poor” in BER, and that of %G was “average-good” in HAN and “good” in BER. From this result, this match can be analyzed as follows. In this match, HAN’s attack could be continued without being stopped by the opponent defense player,

Conclusion

In this study, we was to develop the useful statistical data indexes to evaluate the team performance of attack and defense during handball match, based on terminate of attack or defense phase. Therefore, We demonstrated that %G, xTO and xRTF on attack phase and %L, OppxTO and xTFT on defense phase are important and strong indexes in order to conduct a more detailed match analysis. %G has a positive effect and xTO and xRTF have a negative effect on the goal scores in attack phase. %L has a negative effect and OppxTO and xTFT has positive effect on the opposing goal scores.

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Kinematic Analysis of Throwing for Handball Player

- The Differences Between Using the Sticking Tape and the Sticking Gel –

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Summary

The purpose of this study was to reveal the difference of motion between using the sticking gel and the sticking tape, to propose the environmental improvement, and to provide the latest research based information for coaching young generations. As the results, there were differences of range of motion (ROM) for the maximum external rotation, the flexion of elbow, and the extension of wrist between two conditions while throwing the ball.

Keywords: handball, sticking tape, ROM

Introduction

Now the Tokyo 2020 is close at hand, Japan has been excited to be host at the Olympics. Japanese Handball Association vigorously has strengthened the level of Japanese teams, and one of the strengthening actions for men's Japanese team was to hire Dagur Sigurðsson as a new head coach. Even though these actions, men's Japanese team ended up as the lowest rank among participated 24 countries at the 2019 Handball World Cup in Germany and Denmark. As the reasons of such a result from the World Cup, it was indicated that there were difference of experience playing at international games and in physique between Japanese team and the other national teams. On the other hand, there is the original handball culture in Japan regarding the training environments for young generation. It is that players whose ages are between elementary school and university are allowed only to use the sticking tape instead of the sticking gel in their competitions. Because of that, the purpose of the study was to verify the difference of motions while using the sticking tape and the sticking gel when throwing the ball and to provide the latest information for coaching young generations by revealing the reason for the difference.

Methods

Subjects:

At first, the motions of throwing were recorded by 8 video cameras(250Hz) (Fig.1) in order to reveal the difference of throwing motions while using the sticking tape and the sticking gel. All data were collected during August through September in 2019, and seven male handball players (19.86 ± 1.46 y, 174.86 ± 5.75 cm, and 67.89 ± 5.33 kg) who played at Division I in Tokai Student Handball organization participated in this study. The protocol as well as the purpose of this study were explained to all participants in writing, and the agreements from all participants were collected prior to the experiment. The permission from all participants to use the collected data to the study were also obtained prior to the experiment.

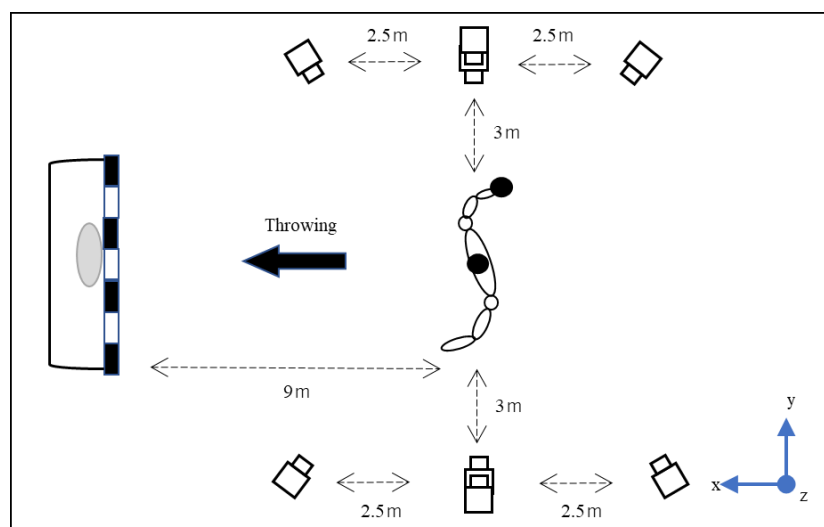


Fig. 1 Schema of experimental setup

Measurement parameters :

According to Miyanishi et al.¹ whose study was about baseball, the maximum external rotation of shoulder was most important phase to affect transferring energy to the thrown ball. They also indicated that the internal rotation of shoulder, the extension of elbow, and the flexion of wrist also highly contributed to the motion of throwing. Therefore, the external and internal rotations of shoulder, the flexion of elbow, and the extension of wrist (Fig. 2-4) during throwing motion were analyzed in this study. The motions of throwing were recorded by the three-dimensional motion capturing system, and the collected data were analyzed by the three-dimensional analysis.

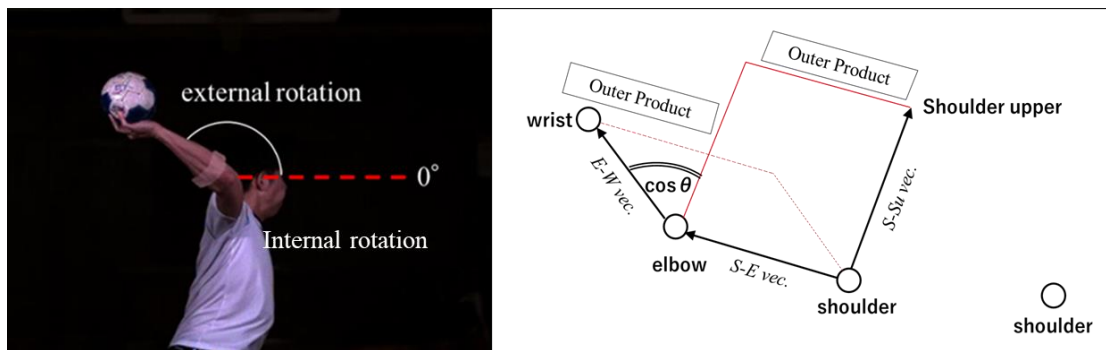


Fig. 2 Rotation of shoulder

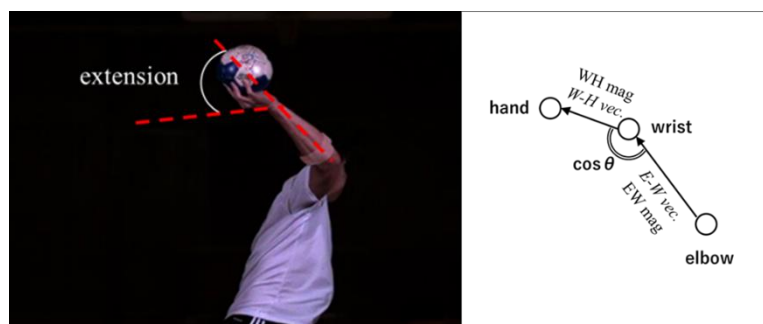


Fig. 3 Extension of wrist

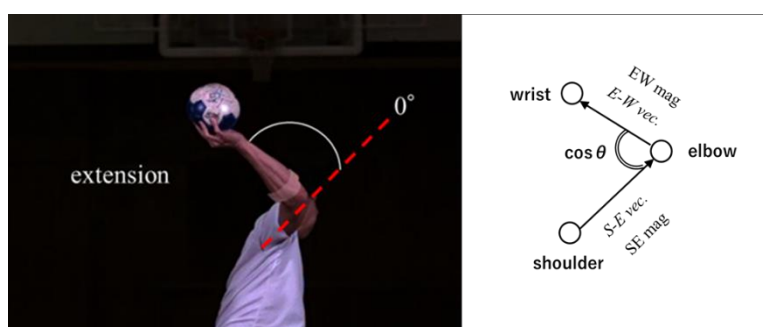


Fig. 4 Extension of elbow

Condition of throwing:

After enough warming up, all participants performed the straight shot by the three speeding-up steps aimed at the upper row of the goal with their maximum efforts at the distance of 9m from the goal. Participants performed 3 throwing trials on each condition that were with using the

sticking tape and gel. However the extra throwing was allowed in the case if a participant was not satisfied the throwing or missed aiming the thrown ball to the upper row of the goal.

Statistical analysis:

All data were shown as mean±SD. For conditional comparison among the maximum external rotation and internal rotation, the flexion of elbow, and the extension of wrist, the unpaired t test was employed to reveal relevance to each condition. Statistically significance of the results was set at 5%.

Result and Discussion

Mean ROM for the external rotation of shoulder, the difference of ROMs between using sticking tape and gel, and the maximum ROMs for external rotation of shoulder with using sticking tape and sticking gel were shown in Table 1 and Fig. 5. To use the sticking gel showed significantly higher ROM than to use the sticking tape at the external rotation of shoulder. On the other hand, there was no significant difference between using the sticking tape and gel at the internal rotation of shoulder.

Mean ROM for the extension of wrist, the difference of ROMs between using sticking tape and gel, and the maximum ROMs for the extension of wrist with using sticking tape and gel were shown in Table 1 and Fig. 6. Even in the flexion of wrist, to use the sticking gel showed significantly higher ROM than to use the sticking tape.

Mean ROM for the flexion of elbow, the difference between using sticking tape and gel, and the maximum ROMs for the flexion of elbow with using sticking tape and gel were shown in Table 1 and Fig. 7. Even in the flexion of elbow, to use the sticking gel showed significantly higher ROM than to use the sticking tape.

Table 1 Results from two conditions

	tape	gel	*tape vs gel
External rotation of shoulder(°)	144.5±10.4	152.0±8.2	<i>p</i> <0.05
Internal rotation of shoulder(°)	27.6±8.9	30.2±7.8	<i>ns</i>
Extension of wrist(°)	27.8±10.2	39.2±8.5	<i>p</i> <0.01
Flexion of elbow(°)	77.3±11.5	84.8±11.5	<i>p</i> <0.05

*Unpaired t test

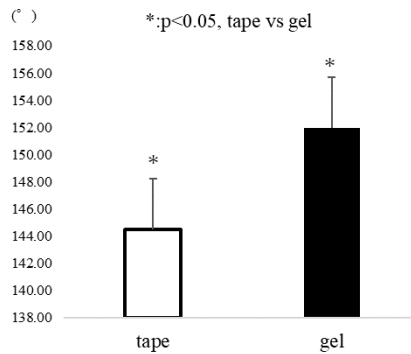


Fig. 5 Maximum external rotation of shoulder

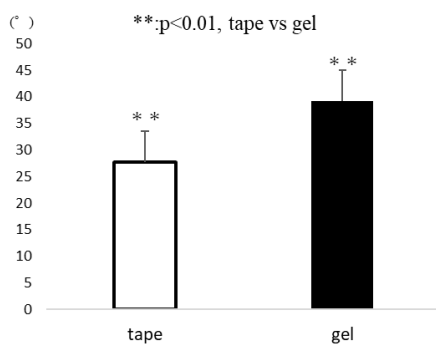


Fig. 6 Flexion of wrist

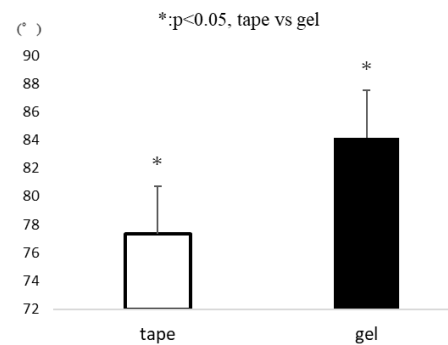


Fig.7 Flexion of elbow

From these results, it was thought that the sticking gel adhered to the ball that led to relax while gripping the ball and created the wide ROMs of each joint that delivered the dynamic motion for throwing. Especially the result from the extension of wrist was significant, and it was thought that to reduce the stress on gripping the ball created the wide ROMs of each joint. Contrary to expectations, it was suggested that to use the sticking tape restricted the wide ROMs of each joint that each participant had. It was also suggested that these restrictions of the ROMs affected throwing skills. Young generations whose are allowed only to use the sticking tape during the practice and the game required to re-learn how to throw the ball with using sticking gel when they moved to the level where the sticking gel are allowed to use. It was also thought that the changes of gripping force due to using the sticking gel affected not only the way to throw the ball but also the way to pass or catch the ball.

On the other hand, there were some participants who did not show significant differences between using the sticking tape and gel. From the above, it was suggested that the strength of muscle and the level of skills for throwing needed to be considered for the future research. From

the perspective of injury prevention, Miyanishi et al. reported that the risk of the injury to the shoulder increased as the ROM for the external rotation of shoulder increased, and also the risk of the injury to the elbow increased as the ROM for the flexion of elbow increased. Therefore the prevention of injury would be one of the subject that needed to be considered when players began to use the sticking gel.

Conclusion

In this study, it was revealed that using the sticking gel while throwing the ball increased the ROMs for the external rotation of shoulder, the flexion of wrist, and the flexion of elbow by comparing with using the sticking tape. Young generation of handball players in Japan will need to prepare for re-learn how to throw the ball with using sticking gel when they face to play at international games. Therefore, young generation of handball players in Japan should begin using the sticking gel as important as learning tactics and training physical strength in order to fill the gap between Japanese handball team and the other international teams

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INJURY, PREVENTION AND RECOVERY – PSYCHOLOGICAL BACKGROUND AND APPROACH

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Summary

This paper is a short literature review aimed to briefly describe the perspective on the sports injury psychology through an analysis of recent literature and research done in this domain. The main objective is to raise awareness and develop an insight into the significance of psychological interventions on athletes during the training and competition period as pre-injury mental states, and the effects psychological interventions have on the recovery, post-injury, process.

Keywords: psychology, sports injury, prevention, recovery, psychological interventions

Introduction

Sport injuries threaten athletes' career and success (O'Connor et al., 2005). Although some injuries are smaller and do not have any impact, there are others that can end a career and have consequences on athletes' quality of life. Moreover, injuries determine rehabilitation costs, which concern athletes and/or sport organizations, in terms of monetary costs or lost time (Santi & Pietrantonio, 2013).

Some athletes seem to be injury prone, whereas others are rarely on the sidelines for medical reasons. It seems likely that the most aggressive athletes are the most injured, but it could be the other way around. Are there certain personality types that show a greater tendency to be injured than others? Sports fans greatly admire seriously injured players who return to the game in record time in spite of obvious continuing discomfort. Still, a few athletes are known to have required psychological treatment during rehabilitation. Why does this difference exist? Fear of the outcome of an injury on pain and performance is surely an important factor in determining how fast rehabilitation occurs. Should coaches use specific strategies to help athletes better cope emotionally with their injuries? Can these strategies accelerate the return of the athletes to competition? (Gould, Petlichkoff, Prentice & Tedeschi, 2000).

Over their careers professional athletes spend thousands of hours in training. Despite this, or because of, they have a risk of injury higher than normal exercisers (Brewer, 2009). For example, in windsurfing there is a probability of 0.22 injuries every 1000 hours of practice among amateur performers, but these data rise till 13 injuries every 1000 hours among professional performers (Perez-Turpin et al., 2012a). Vitale (2011) provides the example of gymnastics and football: the 70/80% of professional female gymnasts occur in an injury every season and the 75% of professional football players (both men and women) have injuries every season.

There are also gender differences. According to US data about recreational sports men are generally more liable to occur in an injury if compared with women (NEISS, 2010). For example, injured men in baseball are twice than injured women, and in basketball injured men are four times than women. However, there are some exceptions, in horse riding injured women

are more than men. Unfortunately, these data do not consider the number of participants and do not provide any information regarding professional sports. Research on elite performers is limited and most of the studies consider individual sports (Santi & Pietrantonio, 2013).

The incompleteness of these data is due to the difficulty to uniform data from different countries, and the fact they are collected in different ways (Van der Sman et al., 2003). Moreover, there is a lack in the literature about epidemiology of sport injuries among professional athletes, and therefore it is not possible to determine the gap between professional and recreational sport, and the incidence of different risk factors on sport injury (Giustini & Cedri, 2002). It is very likely that one of the reasons few psychological studies have been done on sport injury prevention is the shortage of this data. Where as the research on the rehabilitation process is done more often, therefore offering us more data and valuable information.

An injury does not only affect physical capabilities, but also contextual and psychological aspects. Injuries can deprive athletes of their compensation increasing life-stress, and determine fear of reinjury, sensation of loss, negative emotions, and other mood disturbances (Sparkes, 2000; Vergeer, 2006; Naoi & Ostrow, 2008). The negative impact of injury depends only in part on how much time athletes have spent in sport – high performers, who have a stronger athletic identity, experience major feeling of loss and mood disturbance. However, they also have a better reaction to the injury, probably because they have more psychological resources to cope with the situation (Rees et al., 2010). For these reasons, during the rehabilitation process athletes may benefit of the support from relevant social agents and of the intervention of a psychologist (Santi & Pietrantonio, 2013).

Therefore, taking all this in consideration, preventing a sports injury is a domain that is still needed to be invested in more. Researchers interested in this aspect accent the importance of cognitive ability, that is often an underrated part of sport performance. Handball is a fast and dynamic team sport, during which multiple stimuli are targeting sensory organs of players and triggering high cognitive demands, testing mental skills such as concentration, anxiety, attention shifting, negative thoughts and the subsequent physical reactions that accompany these skills. In sport, the best players are those players who not only have the skill and tactical knowledge of the game but have enough perceptual and cognitive ability to outplay other players (Murphy, 2013). We are all aware that injury is common in elite sports with significant consequences and re-injuries as a major concern. If we could be able to introduce strategies to reduce the risk of incurring to an injury or even to accelerate the recovery time after an injury and reduce the re-injury risk in players then, this can contribute greatly to the performance of the individual and the team (Orchard, 2012).

Development

In the domain of injury prevention, one of the first questions that arises is if there could be a relationship between cognition and injuries during sport matches. Game intelligence is a key part of performance and encompasses numerous parameters including information processing, experience, decision-making, reaction time, memory and recall, vision, sensorimotor processing, attention, anticipation, cognitive styles, time, and space perception. Potential stressful athletic situations can contribute to injury (Williams & Anderson, 2004).

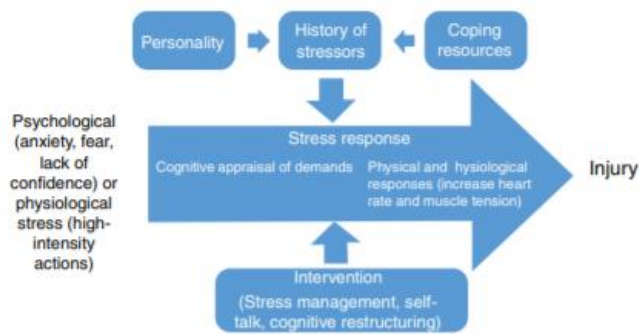


Figure 1 Cognitive appraisal of demands in stress response
Adapted from Williams J & Anderson M. 1998.

Stress leads to decreased neurocognitive and perceptual processes, increasing reaction times, and compromising game intelligence. Exposure to stressors for extended periods also decreases communication between the left and right hemisphere of the brain compromising decision-making. Decreased decision-making ability has been related to increased injury risk according to literature (Ivarsson et al., 2017).

Since the injury rate is higher in matches than during training, it is important to analyse the additional risks associated during a match. One of the most important aspects is the fact that matches have higher levels of unanticipated actions, and training situations tend to be more controlled. The cognitive and decision-making elements, as well as pressure situations linked with matches, can result in changes in biomechanics and execution of actions (Sugimoto et al., 2015).

This highlights the importance of cognitive training as a part of injury prevention. Skill levels also correlates with the changes in biomechanics during football actions in matches and in training (Sugimoto et al., 2015).

Stress management is one of the key tools used to both improve decision-making and subsequently decrease injury risk. Decreasing stress levels correlate positively with a reduced activation of the amygdala which improves the players' attention and the decision-making process. Other interventions that have also given good results are aimed at teaching players how to improve attention and be more mindful in both training and matches (Ivarsson et al., 2017).

While attention itself is important, it is also important that players develop the skills to shift their attention. Players need to have sport specific knowledge and learn what, when and where to focus on it. There are periods in the game when players must broaden their focus and when to narrow it. Broad focus refers to accessing numerous stimuli and seeing the bigger picture, whereas a narrow focus is when a player zooms into specific stimuli. Players must also know when to broaden and narrow their attention. The ability to identify when and how to adjust attention can be taught during training by increasing a player's awareness to what type of information he needs in different situations. These skills should be included in talent development programmes. These skills can be taught by increasing their conscious awareness in training when starting out with cognitive training. Other interventions aimed at getting players to learn to 'switch off' negative thoughts, and also when to switch off during in-match breaks and refocus when is needed. Players can be taught these skills, and to use key words or phrases as triggers (Bahdur, 2016). Self-talk is one of the greatest weapons a player has. In addition to helping players let go of mistakes and focus on the present, it can also translate into better body

language and movements for the player (Abrahams, 2014). Visualisation and relaxation interventions and strategies can also be used to reach the objectives. Visualisation enables the body to go through physiological changes without any movement and to store the patterns in the temporary memory. These patterns can then be converted into the short or long-term memory (Bahdur, 2016). Teaching players to relax before and during matches decreases stress and anxiety levels, and can reduce their risk of injury.

During a rehabilitation period, a variety of psychological interventions have been found useful, and in the re-entry period - educational interventions, goal setting, imagery, self-talk based interventions, biofeedback, and social support based interventions. Emotions can be managed through education and imagery. Athletes should be prepared also about their oncoming emotions, such as frustration, anger, or mood swings. It is also necessary that they are conscious of their role in the rehabilitation program, and the importance of their compliance with the medical staff. Finally, athletes' motivation may be enhanced by intervening directly on the athlete through goal setting or with the provision of social support (Santi & Pietrantonio, 2013).

Education can make athletes aware of their situation. Research has shown how the athletes do not have a clear vision of the rehabilitation process immediately after the injury and this can determine negative emotions and demotivation. Moreover, athletes think a better knowledge of the rehabilitation process permits to see realistically the situation and reduce anxiety (Francis et al., 2000). That is why it is important to intervene in the early stages of the rehabilitation.

Although few studies have evaluated the effectiveness of support interventions in enhancing sport injury recovery, social support has recently been receiving increasing attention in the specific context of rehabilitation (Rees et al., 2010). Social support based interventions have different effects depending on the source and type of support. For example, emotional support provided by family, physiotherapist and others, has an effect in reducing depression, where the informational support reduces anxiety and increases self-confidence. Finally, appraisal support provided by other injured athletes determines an enhancement in coping strategies, treatment motivation and satisfaction, and a reduced fear to reinjury (Rees et al., 2010; Handegard et al., 2006; Hogan et al., 2002).

Conclusions

This was an overview of the literature and research on psychology of sport injury prevention and rehabilitation, the leading psychological interventions and their effectiveness. Psychology may complete the knowledge about sport injury prevention and rehabilitation, minimizing the risk of secondary injuries and reinjuries. Psychological interventions can provide a comprehensive service to athletes.

A significance to keep in mind is that injury prevention techniques are not a 'one size fits all' – rather an interaction between personal (physical and psychological), environmental and contextual characteristics, and how they affect the persons' cognitive-affective-behavioral processes before, during and after injury occurrence, at different phases of rehabilitation, and during the return to activity or retirement from activity process (Arvinen-Barrow, 2018). This is to be considered when preparing a prevention or a recovery program.

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SHOT FREQUENCY AND SUCCESS RATE OF VARIOUS TYPES OF THROWS FROM BACK COURT POSITIONS

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Summary

This quantitative study conducted identifies the effectivity of shots from Handball back court players depending on their range to the goal by analyzing games from the EHF World Championship 2019. It herewith compares the general effectiveness measured in goals from long distance or attempts from the six-meter line. During the course of investigation, success is not only measured when a back-court player scores a goal but also when he is granted a penalty shot. Adding this factor to the rate of success, the study ultimately finds that when back court players attempt a shot on the goal from close range, the likelihood for success is significantly higher than when they shoot from the back-court.

Keywords: Handball, shot frequency, success rate, back court positions

Introduction

In every sporting competition, success depends on a vast variety of criteria. One of these criteria in Handball is the goal scoring efficiency from back-court players, which is influenced by the various and different positions of the player (angle to gate), as well as the distance between the player and the goal (Konstantinidis & Bekoulis, 1984). Previous studies found that, approximately, half of the throws at the goal are performed from the left and right back court positions (Alexandru et al. 2009; Evangelos et al. 2006) and that jump throws occur more often than other types of shots (Prevena et al. 1994; Wagner et al. 2008). Therefore, this study aims to compare the efficiency of goal attempts following 1 vs. 1 situations and breakthroughs, with throws from the back-court, including jump shots and set shots.

With the hypothesis that throws on the goal after 1 vs. 1 situations and after breakthroughs from six meters are more promising than hitting set or jump throws from the long-distance, attention should be drawn onto the possibility of changing training and game control depending on the outcome of this study.

Methods

Twelve games of the EHF World Championship 2019 with a total of 16 teams were analyzed. Variables considered include the frequency of the different types of throws and their respective scoring rate. All goal attempts were counted, herewith differentiating between goal attempts from the back-court via set or jump throws and from close range after 1 vs. 1 situations or breakthroughs. The analysis was concluded from attempts by the back-court position players that either lead to a goal or to a change in possession of the ball. Breakthroughs, herewith, are considered situations, in which a back-court player, either through winning a 1 vs. 1 situation or via precluding team actions, can take a shot at the try line unhampered. To properly evaluate the efficiency, the rate of success is based on every action from back-court position players that

either lead to a direct goal or being granted a penalty shot. The data was then statistically analyzed through a χ^2 -test.

Results

The results of the study reveal that differences in the frequency of the various types of throws, as well as in the efficiency of the throws themselves, were significantly notable between the two groups.

First and foremost, it's important to highlight that there has been a total of 476 attempts from which 61% came from the back-court and 39% from close range. This is of particular interest, as it serves to evaluate, understand, and interpret the subsequent results. In general, and on average, the back-court players take more attempts from longer distances than from close range.

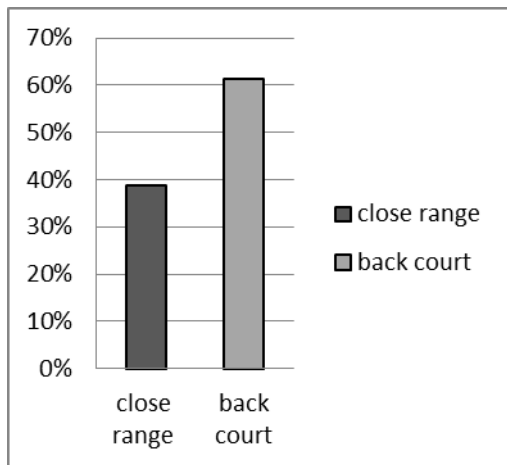


Fig. 1: Percental amount of the two different types of throws from all shots taken.

Comparing the respective goal efficiency between the two distinctive types of shot ranges, it is apparent that, measured in goals, especially shots from the back-court lead to the same rate of success (33% of total shots) or failure (34% of total shots).

In contrast to that, shots taken directly from the six-meter line are more likely to lead to a goal (23%) than to a missed attempt (10%). The χ^2 -test showed a highly significant result in which throws after 1 vs. 1 situations or breakthroughs are more likely to lead to success than long distance attempts. ($\chi^2(1) = 18,129$, $p = .001$, RR [close range/back court] = 2,517, 95% CI = [1,636; 3,871])

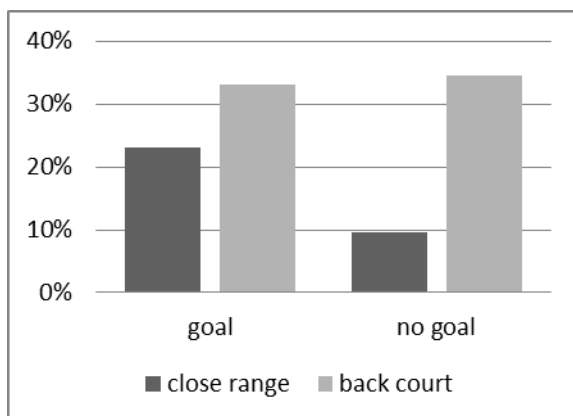


Fig. 2: Percental quantity of throws leading to goals or no goals depending on distance to goal.

The aforementioned results are affirmed when adding penalties as a factor of success ($\chi^2(1) = 38,034$, $p = .001$, RR [close range/back court] = 3,585, 95% CI = [2,364; 5,435]) (Fig. 4). Due to their likelihood of scoring a goal, which is assumed to be higher, because a penalty shot is a direct and unhampered shot against the goalkeeper from close range. The results are corroborated by comparing the relative frequencies of penalty throws granted, which is 24% after close range tries and about 0.01% after long range attacks (Fig. 3).

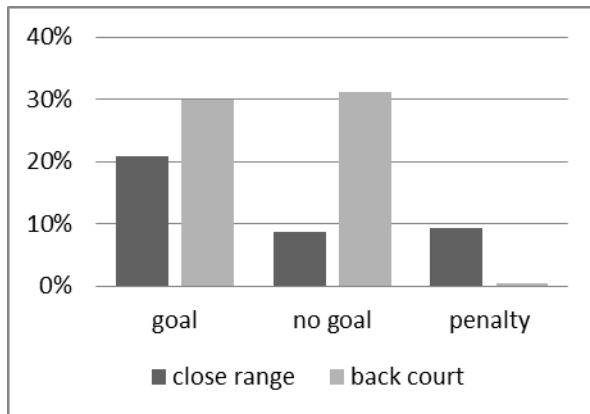


Fig. 3: Percental quantity of throws leading to goals, no goals or penalties depending on distance to goal.

On an important note, there seemingly is an equal percentage of absolute success (goal or penalty) after long- and close-range attempts (Fig.4). Yet, considering the absolute frequency of attempts overall, the rate of failure is higher after back-court shots due to the larger amount of shots taken.

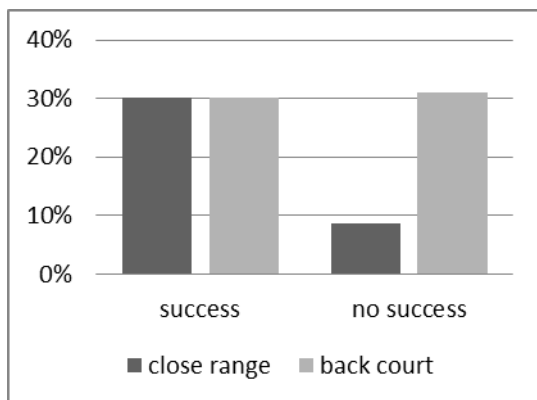


Fig. 4: Percental quantity of throws leading to success (goal or penalty) or failure (no success) depending on distance to goal.

In particular, these results confirm that throws following 1 vs. 1 situations or breakthroughs are more efficient than jump or set throws from the back-court, as there are, in total, less attempts required to result in the same amount of success.

Discussion

Nevertheless, in absolute terms, goals are more frequently scored from longer distances in the back-court. Overall, more goals are scored from these distances, as the total amount of back-court shots is simply higher than the rate of breakthroughs. Hence, specific shot training should be implemented into team routines in order to increase the overall efficiency of these throws. More effective back-court shots will ultimately lead to changes in the opponent team's tactics, for example a more offensive approach to their defense against players with high shot efficiencies from the back court. This will, ultimately, lead to large spaces at the try line, giving other back court players larger openings for the more efficient throws from breakthroughs.

From a defensive perspective, training should also be focused on forcing the attacking team to take more and also less efficient shots from the back court. This could be executed by letting offensive back defenders force the back-court players to take shots from unusual angles (for example right handed left back forced to throw from the right back position) or attempts against a defensive double block.

Furthermore, additional studies could emphasize research to validate if the given research can also be transferred to amateur teams. As, in recent years, even amateur teams started to analyze their respective opponents prior and after their matches. This leads to a gathering of information that can be used to adapt play style and formations in upcoming matches. Especially, if the opposing team has back-court players with high shot efficiency rates from larger distance, an offensive approach to a team's defense, like the 3:2:1 defensive formation, can lead to a decrease in the opposing team's back-court shot efficiencies from individual players that, for example, have weaknesses in their 1 vs. 1 actions.

Moreover, from additional or complementary research to this study, it should be monitored if, in the case that efficiency from the long-distance shots increases, teams actually react and reinforce a groundbreaking change in their respective defensive systems.

Conclusion

Conclusively, the findings on the different effectiveness of shots from back-court players enable specific training and game control opportunities. They should therefore serve to be considered for complementary fitness program planning, as well as for offensive and defensive decision-making and tactical evaluation. The study identified that back-court players' attempts from the 6-meter line, in this case after breakthroughs or winning a 1 vs. 1 action, are, statistically, significantly more likely to lead to success than long-distance approaches onto the goal. This confirms the aforementioned hypothesis. The discussion identified a variety of potential outcome, hereby highlighting that focus on training should be stressed on increasing the shot efficiency from long-range shots on an individual level for back-court players. This is due to the fact that these types of shots simply occur in larger amounts given their relative frequencies. In the study, success and failure from larger distance attempts were nearly equally split in terms of percentage from the overall attempts taken from the back-court. Hence, increasing individual efficiency will lead to higher success rates for teams.

On the other hand, the findings from this study also serve trainers and staff to focus on complementary fitness program planning in order to enable back-court players to more often aim for breakthroughs and 1 vs. 1 situations – for example after tactical precluding routines – as these attempts are significantly more likely to lead to success but are also physically more exhausting for the individual players as they oftentimes include heavy physical contact. This can be derived from the fact there has been a considerably larger amount of penalties been granted after these situations than from back-court attempts.

Ultimately, the findings do not only undermine the challenges for offensive coordinators, but also for the constitution of teams' defensive approaches. As another practical implication, it can be derived that, from a defensive perspective, individual back-court players with more than average efficiency and should thus be defended more offensively to force them into off-angle shots, herewith decreasing the individual rates of success. Thus, defensive coordinators can take open defensive approaches like that of a 3:2:1 or 4:2 defensive system into account to force these back-court shooters to take the, physically more exhausting, 1 vs. 1 actions.

After all, the study implies that, for example, real-time information on these individual statistics could lead to beneficial game control decision-making processes and might potentially lead to both defensive and offensive on-the-spot decision-making during games, rather than preparing for a game and starting with a fixed and set game plan. It will thus be interesting to see if the game of Handball herewith becomes even more tactical with new technologies allowing real-time statistical analysis during the game.

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MOTOR AND MORPHOLOGICAL DIFFERENCES BETWEEN YOUNG FEMALE HANDBALL PLAYERS FROM THREE AGE GROUPS

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Summary

The study aimed to establish whether any statistically significant differences exist between three age categories of elite young Slovenian female handball players in terms of the results achieved in some motor and morphological parameters. For this purpose, members of the Slovenian female national team born in 1998/99 and 2000/2001 were selected so that their average respective age was 15, 17 and 19 years. The set of motor measures included 12 parameters covering various motor areas relevant to handball. The measures defining the subjects' morphological status included 8 parameters or appropriately calculated indices (Šibila and Pori, 2009). The number of subjects differed each year, although all three measurements were carried out with the 29 subjects included in our study. All measurements were conducted by the same people, using the same measurement technology. The results were processed with descriptive statistics methods and the differences between the groups were established using a Kruskal-Wallis test. The results showed that statistically significant differences between young female handball players aged 15, 17 and 19 could not be confirmed in the most of the studied parameters. Obviously, 15 is the age at which those female players who were included by their coaches among the ranks of talented national team players have reached their biological maturity in morphological and motor terms. The majority of morphological characteristics and motor abilities are highly genetically conditioned. Thus, only statistically significant differences were established between players older than 15 years in terms of amount of muscle mass, somatotype, 5 m and 10 m sprint time and 30-15_{IFT} test. Evidently, the training factors do not provide a sufficiently strong stimulus for the development of other motor abilities.

Keywords: *elite handball, motoric, morphology*

Introduction

The physical part of a team handball game consists of a combination of intense, intermittent activities such as running, sprinting, jumping as well as regular struggles between players – holding and pushing (Jensen, Johansen, & Liwendahl, 1999). Morphological characteristics of the body and motor abilities certainly have a great influence on an outstanding performance in handball (Jensen, Johansen & Larsson, 1999; Šibila, Pori, 2009, Mohamed, et al., 2009). That is particularly typical of top handball, where the advantages of players with a suitable morphological and motor structure are evident (Rannou, Prioux, Zouhal, Gratas-Delamarche, & Delamarche, 2001). Recent research studies dealing with the morphological profile of a top-level handball player highlighted that they are characterised by a prevailing mesomorphic somatotype with a touch of ectomorphy, that is, with a pronounced longitudinal dimensionality of the skeleton (Šibila and Pori, 2009). In terms of handball players' motor structure, the most prominent are the explosive and elastic power of the legs, arms and shoulder girdle, sprint speed

and specific aerobic endurance (Šibila, 1989; Jensen, Johansen & Liwendahl, 1999). Due to the above, measurements of morphological physical characteristics and motor abilities are used in the identification and further selection of talented individuals (Šibila, 1996). Apparently, in sport games performance also correlates with some other abilities, characteristics and qualities (Falk, Lidor, Lander, & Lang, 2004). In Slovenia, the aim of the systematic measurements of handball players at the national level is to objectivise the assessment of an individual player's talent and thus influence their inclusion in national teams at various development levels (Šibila, 2009). In small countries it is particularly important that the monitoring of players' development is systematically supported and underpinned by scientific findings (Bloomfield, Ackland, & Elliot, 1994). In addition, the acquired results are used to help plan the training of the measured individuals (Šibila, 2009). Namely, the selection of talented players is a continuous process of identification of those who, at different development levels, meet the requirements for joining handball teams (Mohamed, et al., 2009). Yet it should be considered that the complexity of identifying talent relates to both a genetic predisposition (Bouchard, Malina, & Pérusse, 1997) and the capacity to improve through intensive training (Ericsson, Krampe, & Tesch-Römer, 1993; Reilly, Williams, Nevill, & Franks, 2000). To acquire relevant data from the discussed areas, a special measurement system was developed in Slovenia for three age categories of young female handball players of the national team, namely with a respective average age of 15, 17 and 19 (Šibila, 2009). The applied measurement procedures covered the majority of abilities and characteristics relevant to handball players' efficiency.

Our study aimed to establish whether any statistically significant differences exist between three age categories of elite young Slovenian female handball players in terms of the results achieved in some motor and morphological parameters. We wanted to ascertain whether biological development and the effect of training elite Slovenian female handball players at an age between 15 and 19 bring about any changes in the morphological physical and motor areas.

Methods

Sample

In the framework of regular measurements of morphological physical characteristics of female handball national team players of younger age categories, we measured 29 female players born in 1998/99 and 2000/01. The measurements were carried out in the years 2015, 2017 and 2019. The number of subjects differed each year, although all three measurements were carried out with the 29 subjects included in our study. At the time of measurement, the study subjects were 15.3 ± 0.28 , 17.8 ± 0.28 and 19.6 ± 0.28 years old on average. Their average body height was 171.08 ± 5.27 cm and body mass 65.05 ± 7.05 kg.

Variables

The assessment of morphological physical characteristics was based on the standard anthropometric battery with 24 dimensions used to calculate the percentage of muscle and bone mass, subcutaneous fat values and the subject's somatotype (Duquet, & Hebbelinck, 1977). Somatotypes were determined using Heath-Carter's method (Carter, & Heat, 1990). Endomorphic, mesomorphic and ectomorphic components were calculated with a computer on the basis of formulas (Duquet, Van Gheluwe, & Hebbelinck, 1977). The assessment of the explosive and elastic power of the legs was made using the Tensiometric plate; the study subjects performed two different jumps: a squat jump (SJ) and a counter movement jump (CMJ). The ability to generate sprint speed was assessed using sprint times over 5, 10 and 20 m with a standing start (T_{5m} , T_{10m} and T_{20m}) and a flying start (FT_{5m} , FT_{10m} and FT_{20m}). Running

endurance (maximum aerobic speed) was assessed using the 30-15_{IFT} test (Buchheit, 2005a; Buchheit, 2005b). This is an intermittent fitness test (with interruptions) performed on a handball court – 30 s of running and 15 s of rest. The subjects were running at a pace dictated by a sound signal. The running speed increased with each repetition and the runners persevered until exhaustion or so long as they were capable of running the specific distance foreseen in the interval. The subjects wore heart rate monitors. The explosive power of arms and upper body was determined by ball throwing velocity at ground shot and jump shot using radar technology to measure it. The ball size 2 with handball glue was used. All measurements were conducted by the same people, using the same measurement technology and same measurement protocols.

Table 1: Sample of variables

Test	Measured capacity	Measuring unit
Body height	Longitudinal dimension of the body	mm
Body weight	Body mass	kg
% of muscle mass	Amount of muscle mass	%
% of bone mass	Amount of bone mass	%
% of body fat	Amount of body fat	%
Ectomorphy	Ectomorphic component of somatotype	share
Mesomorphy	Mesomorphic component of somatotype	share
Endomorphy	Endomorphic component of somatotype	share
5-m sprint – standing start	Sprint speed	seconds
10-m sprint – standing start	Sprint speed	seconds
20-m sprint – standing start	Sprint speed	seconds
5-m sprint – flying start	Sprint speed	seconds
10-m sprint – flying start	Sprint speed	seconds
20-m sprint – flying start	Sprint speed	seconds
“30-15” _{IFT}	Aerobic endurance	km/h
VO ₂ max	Maximal O ₂ consumption	ml/min/kg
Squat Jump	Explosive power of leg	cm
Counter Movement Jump	Elastic power of leg	cm
Ground Shot Ball Velocity	Explosive power of arms and upper body	km/h
Jump Shot Ball Velocity	Explosive power of arms and upper body	km/h

Data analysis

The data were analysed using the statistical package SPSS 22.0. Basic parameters of the distribution of variables were calculated (mean, standard deviation, minimum and maximum values, kurtosis, skewness and Kolmogorov-Smirnov test of variables). Since not all the parameters were distributed normally non-parametric tests (Kruskall-Wallis test and Mann-Whitney test of pairs) were used to test the differences among the age categories (age 15, 17 and 19 years). A probability level of 0.05 or less was taken to indicate significance.

Results

Table 1 presents the basic statistical characteristics of selected morphologic and motor parameters. The table shows average values, standard deviations, minimum and maximum values, kurtosis, skewness and significance of the Kolmogorov-Smirnov test.

Table 2: Basic statistical characteristics of all parameters and all groups

Parameter		s	min	max	kurt	skew	pK-S
Age	17.57	.81	14.7	18.9			
BH	171.08	5.28	156.7	181.0	.101	-.420	.200*
BM	65.05	7.05	51.8	80.1	-.994	-.083	.082
%MM	46.79	4.24	37.7	54.5	-.772	-.458	.008
%BM	14.78	1.40	12.3	21.6	5.332	1.488	.003
%FM	18.94	3.018	11.3	24.6	-.248	-.460	.098
Ecto	2.89	0.96	0.8	5.2	-.216	.452	.013
Meso	3.75	0.97	1.7	5.8	-.567	.052	.083
Endo	3.03	0.86	1.1	4.7	-.794	-.059	.065
T _{5m}	1.17	0.06	1.06	1.31	-.587	.359	.004
T _{10m}	1.99	0.08	1.83	2.17	-.491	.427	.020
T _{20m}	3.41	0.12	3.17	3.75	-.135	.556	.066
TF _{5m}	0.73	0.028	0.68	0.81	.077	.725	.000
TF _{10m}	1.42	0.057	1.33	1.58	.107	.627	.077
TF _{20m}	2.77	0.12	2.55	3.1	.158	.638	.171
“30-15” _{IFT}	16.68	1.25	13.0	19.5	.593	-.431	.001
VO _{2max}	43.48	2.30	38.4	48.6	-.348	-.078	.200*
SJ	25.36	3.35	18.0	34.71	.001	.191	.200*
CMJ	27.13	3.16	17.4	34.1	.002	-.195	.200*
GS	77.76	6.01	63	90	-.403	-.150	.200*
JS	76.50	5.78	61	88	-.189	-.159	.200*

Legend: \bar{x} - average values; s - standard deviations; min – minimum values; max - maximum values; kurt – kurtosis; skew – skewness; pK-S – significance of the Kolmogorov-Smirnov test; : BH - Body height; BM - Body mass; %MM - Amount of muscle mass; %BM - Amount of bone mass; %FM - Amount of body fat; Ecto - Ectomorphic component of somatotype; Meso - Mesomorphic component of somatotype; Endo - Endomorphic component of somatotype; T_{5m} - 5-m sprint – standing start; T_{10m} - 10-m sprint – standing start; T_{20m} - 20-m sprint – standing start; TF_{5m} - 5-m sprint – flying start; TF_{10m} - 10-m sprint – flying start; TF_{20m} - 20-m sprint – flying start; “30-15”_{IFT} – velocity at the end of intermittent fitness test; VO_{2max} - Maximal O₂ consumption; SJ - Squat Jump; CMJ - Counter Movement Jump; GS – Ground Shot Velocity; JS – Jump Shot Velocity.

The data reveal that not all measured parameters were normally distributed. Since not all the parameters were distributed normally non-parametric tests (Kruskall-Wallis test) were used to test the differences among the age categories.

The following tables show the results of Kruskal – Wallis test based on which we established whether there were any statistically significant differences among the three different age categories of the players.

Table 3: Mean values and differences in morphological parameters among the three different categories

Parameter	BH	BM	%MM	%BM	%FM	Ecto	Meso	Endo
15 years	170.74	63.98	43.47	14.45	19.03	2.75	3.40	3.16
17 years	171.00	65.23	46.97	14.66	18.93	3.05	3.77	2.79
19 years	171.49	65.93	49.93	15.20	18.87	2.63	4.09	3.13
Sig. F	.858	.591	.000	.173	.987	.240	.019	.187

Legend: BH - Body height; BM - Body mass; %MM - Amount of muscle mass; %BM - Amount of bone mass; %FM - Amount of body fat; Ecto - Ectomorphic component of somatotype; Meso - Mesomorphic component of somatotype; Endo - Endomorphic component of somatotype.

Table 3 shows statistically significant differences in amount of muscle mass and mesomorphic component of somatotype between the three different age categories. The differences could be because of the biological development of the players since there is no extra training for muscle mass development at measured age groups.

Table 4: Mean values and differences in motor parameters among the three different categories

Parameter	T _{5m}	T _{10m}	T _{20m}	TF _{5m}	TF _{10m}	TF _{20m}	“30-15” _{IFT}	VO _{2max}	SJ	CMJ	GS	JS
15 years	1.19	2.00	3.42	.72	1.42	2.76	17.20	43.73	24.23	26.50	76.54	74.95
17 years	1.17	1.99	3.41	.73	1.42	2.76	16.98	43.29	25.41	26.83	78.97	77.07
19 years	1.14	1.96	3.38	.73	1.43	2.79	15.78	43.42	26.43	28.06	77.76	77.48
Sig. F	.002	.048	.619	.748	.837	.605	.000	.855	.067	.105	.300	.148

Legend: T_{5m} - 5-m sprint – standing start; T_{10m} - 10-m sprint – standing start; T_{20m} - 20-m sprint – standing start; TF_{5m} - 5-m sprint – flying start; TF_{10m} - 10-m sprint – flying start; TF_{20m} - 20-m sprint – flying start; “30-15”_{IFT} – velocity at the end of intermittent fitness test; VO_{2max} - Maximal O₂ consumption; SJ - Squat Jump; CMJ - Counter Movement Jump; GS – Ground Shot Velocity; JS – Jump Shot Velocity.

Table 4 shows statistically significant differences in 5 m and 10 m sprint time and “30-15”_{IFT}. Since short distance sprints are highly correlated with explosive leg power which partly depend to the muscle mass percentage we can assume that differences could refer to the biological development. The results in specific endurance regress through the development.

Discussion

The results show that statistically significant differences between young female handball players aged 15, 17 and 19 could be confirmed in the parameters measuring amount of muscle mass, mesomorphic component of somatotype 5 and 10 m sprint and “30-15”_{IFT} measuring specific endurance. The improvements of the results could be the consequence of biological development of the players from the point of muscle mass development. The regression in “30-15”_{IFT} is the consequence of lack of training stimuli in the aspect of specific handball endurance. All the other parameters shows no statistically significant differences. Obviously, 15 years is the age at which those female players who were included by their coaches among the ranks of talented national team players have reached their biological maturity in almost all morphological and motor terms. The majority of morphological characteristics and motor abilities are highly genetically conditioned. Thus, almost no statistically significant differences were established between players older than 15 years in terms of the discussed parameters. Evidently, the training factors do not provide a sufficiently strong stimulus for the development of motor abilities.

The finding with the greatest relevance for practice is that, on average, young female handball players reach their biological maturity at the age of 15, after which their biological development alone no longer alters mainly all their motor abilities and morphological characteristics. Some researchers question the use of motor and morphological measurements to identify handball talents and predict players’ playing performances, mainly due to large differences in the subjects’ biological ages (Lidor, & al., 2005). The progression from youth to elite sport is namely a complex process and is far from being a mechanics process (Reilly et al., 2005). Maturation is a major confounding variable when it comes to identifying talent during adolescence (Pearson, Naughton, & Torode, 2006). Our results lead us to conclude that almost all the changes are not statistically significant after the age of 15. Therefore, it is reasonable to use the results of motor tests and morphological measurements at this age to be able to reach conclusions about the final biological status of measured players. This category of players could already be termed a performance-related category. It can be concluded that at this age it is reasonable to carry out in-depth and more sophisticated measurements as the feedback is relevant. This is also important from the economic point of view because such measurements are relatively expensive and need to be implemented restrictively. Using the results thereby obtained, coaches can more easily assign players to playing positions and correct any mistakes made in the previous phases of player selection.

The second finding concerns the training stimuli which should be stronger at this age and should accelerate players' development, mainly in terms of their motor abilities. One cannot be satisfied with the situation that, during four years of training, players have not made almost any progress in terms of their motor abilities. This is particularly important for endurance where the possibility of progress is much higher because the genetic determination is smaller than in motor tasks where high speed and explosiveness is required and we have noticed regression in four years development period. It is obvious that in clubs even the most talented players of their generation do not receive sufficiently effective motor abilities development training at this age. The results achieved by our study subjects in the motor tests were lower on average than those achieved by players of the best national teams of a comparable age.

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ELECTROACUPUNCTURE (EA) TREATMENT FOR TOP ATHLETES IN JAPAN

~ A CASE of TREATMENT of STRAINED CALF MUSCLE in HANDBALL PLAYER ~

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Keywords: handball, muscle strain, electro acupuncture

Introduction

In Japan, physical therapy, including acupuncture, is occasionally used for the management of subacute to chronic sports injuries. The purpose is to regulate the autonomic nervous system without the use of drugs by improving the blood flow to the affected area, and by suppressing pain and excessive sympathetic nerve activity. This treatment is used for top athletes who have strict regulations against drug use. A 0.14–0.25-mm-thick needle is injected in the soft tissues of the affected area to generate nociceptive mechanical stimulation. This stimulation activates various sensory receptor cells and improves circulation using endogenous pain control and peripheral vasodilation. Since the effects of acupuncture have become clear, athletes in Japan have started to select acupuncture as a soft-tissue conditioning method more frequently.

In 2018, the Fukuoka University (FU) Sports Clinic used acupuncture as a treatment method in handball players. In 2018, among all FU handball players (men, n = 42; women, n = 27), 27 men (64.3%) and 21 women (77.7%) were injured. Among the injured players, 15 men and 9 women underwent the acupuncture treatment, which was applied to the periarticular muscles and tendons of the four limbs, and the lumbar region. In all cases, needles appropriate for the muscles, tendons, and nerves that innervate them were either inserted for mechanical stimulation, or the electroacupuncture stimulation treatment (EA) was performed directly. In one case, acupuncture was used for moderate muscle strain in the lower thigh and calf areas.

Preliminary studies on muscle injury have been conducted in mouse models; muscle injuries in these models were induced by forced stretch contraction and subsequent physiological and morphological changes, as well as the exerted muscle strength were evaluated. Indeed, it is

difficult to clarify the detailed mechanisms associated with muscle injury in human; therefore, we have to rely on accumulating case reports to identify effective recovery strategies. Pain, force exertion, and range of motion are the important elements targeted in sports therapies, which are aimed to enable an athlete to return to competitions. Thus, it is important to describe the course of recovery with regard to these clinical symptoms. This study aimed to demonstrate the effectiveness of physical therapy combined with Japanese acupuncture therapy to treat a case of muscle injury in a handball player.

Method

Case of injury:

Moderate injury of the left gastrocnemius muscle (muscle strain)

Patient:

The patient was a 22-year-old woman and a competitive left-handed ace-attacker in the FU Handball Team (height, 161 cm; weight, 57 kg), who played in the right back position. She was a top Japanese university level player. She routinely pursued handball training 3 hours/day, for 6 days a week, and specialized weight training two days/week. The patient had no history of lower limb muscle injuries or Achilles tendon ruptures, and she had not performed any strength training that may have caused the fatigue of calf muscles the day before she sustained the injury.

Nature of the injury and symptoms:

The muscle injury occurred about 1 hour after she started training. Although the patient performed sufficient warm-up exercises, the injury occurred when she jumped to deliver a volleyball spike. The injury was not accompanied by contact with other players or sudden changes in the direction of motion. Immediately after the injury, the patient had difficulty walking independently, manifested severe spontaneous pain, obvious swelling, and restricted ankle range of motion. Based on these symptoms, a case of moderate muscle injury was diagnosed in a medical institution. As a first-aid measure, intermittent cooling and simple fixation were performed maximally for 48 hours after the injury, and the patient used crutches to prevent the injured foot from contacting the ground during gait. The circumference of the middle part of the affected shank was 1.12 times greater than that of the non-affected contralateral side (Fig.1, left pic.). On the 6th day after the injury, the patient could walk independently, without experiencing severe pain.



Fig. 1 *Gastrocnemius after injury. The left side is the affected foot.*

Electroacupuncture (EA) stimulation treatment:

Conventional acupuncture treatment was initiated 2 days after the injury when acute inflammation began to subside, whereas active EA treatment was started 1 week after the injury. The patient was under observation for about 2 weeks since the initiation of EA treatment. A total of 10 acupunctures were performed over the entire posterior area on the left lower limb. Four sub fascial acupunctures were applied around the affected area which experienced the most pressure-pain. A 0.20-mm thick needle was inserted into the skin to a depth of about 2 to 3 cm for 30 min. The depth of needle insertion was determined approximately 1 to 2 cm below the fascia. Furthermore, to contract the entire triceps surae muscle, acupuncture was performed along the tibial nerve from the posterior area of the thigh to below the knee. Electrical stimulation was applied by attaching electrodes directly to the inserted needles at a frequency of 5-10 Hz and voltage of 30 V or less for 30 min. Electrical stimulation was applied below the fascia as well as the on the tibial nerve under the knee to evoke muscle twitch response in the entire shank. The voltage output was adjusted to prevent pain in the affected area.

Physical therapy:

Joint mobilization was difficult to perform because of severe swelling and spontaneous pain for the initial several days after the injury; therefore, regular icing and effleurage were performed. About 1 week after the injury, on resolution of the spontaneous pain, stretching and simple strengthening exercise were started in addition to effleurage.

Measurement items:

1) Isometric strength of the ankle joint (Dynamometer; kg)

The maximum voluntary contraction (MVC) of ankle plantarflexion and dorsiflexion were measured with a dynamometer when the hip, knee, and ankle joint were at 90°.

2) Ankle range of motion (Arthrometer; angle°)

The maximal range of motion of ankle dorsiflexion and plantarflexion in the supine position was measured using an arthrometer.

3) Pain (Algometer; kg)

Pain was evaluated using an algometer (kg) at 5 different sites in the supine position—the centre of gastrocnemius, and the upper and lower parts of the lateral and medial gastrocnemius. Algometry was performed by measuring the pressure at which the patient experienced pain.

All the healthy side data were based on the average values from all measurement points.

Result and Discussion

The MVC of the ankle joint at 1 week after the injury, when the patient was able to walk independently without experiencing severe pain, was 57.5% and 73.7% on plantarflexion and dorsiflexion, respectively, compared to that of the contralateral healthy side (Fig. 2). Assessment of ankle range of motion at 1 week after the injury demonstrated a significant difference in the dorsiflexion angle of the affected side relative to the contralateral healthy side (Fig. 3). The maximal dorsiflexion angles were 48.6° and 15.0° for the healthy and affected sides, respectively, which was 30.8% compared to the healthy side. Pressure-pain in the most severely affected area of the injured side (upper medial area of the shank) was triggered even with a low threshold of 500 g, which was 14.2% of that applied to the contralateral area of the healthy side (Fig. 4). One week after the injury, elasticity of the gastrocnemius during ankle dorsiflexion was impaired, whereas limited force was generated during plantarflexion because of the pain associated with gastrocnemius injury. Particularly, mobility of ankle dorsiflexion was impaired, and the patient experienced pain even during brisk walking.

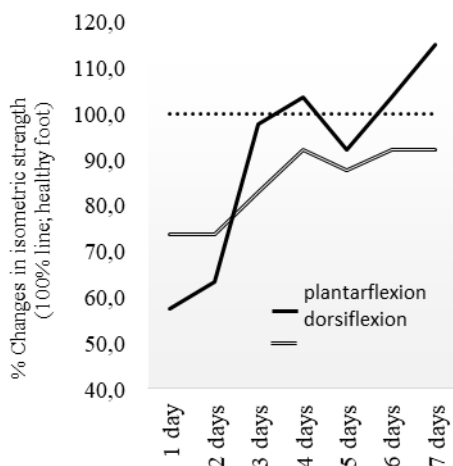


Fig. 2 Ankle joint strength changes (%) after the start of EA treatment

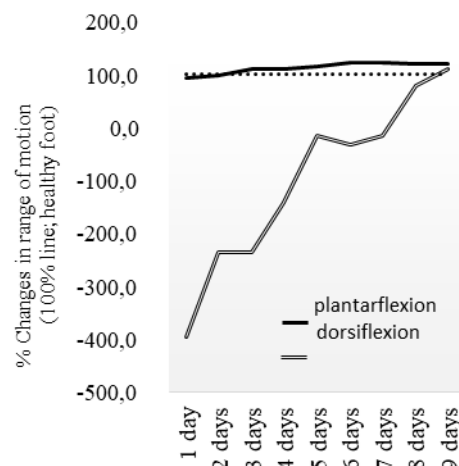


Fig. 3 Ankle range of motion changes (%) after the start of EA treatment

The ankle muscle strength recovered to 90% of the healthy side 4 days after initiation of EA treatment (dorsiflexion, 92.2%; plantarflexion, 103.4%; ratio of the affected and healthy sides) (Fig. 2). Ankle range of motion also recovered at a favorable rate. The maximal dorsiflexion finally reached 100% 9 days after starting EA treatment, whereas the maximal dorsiflexion reached 100% 3 days after initiation of EA treatment (Fig. 3). On subsequent algometry, the pressure-pain threshold in the medial gastrocnemius, the primary site of severe pain, increased to that exhibited by the healthy side on the 8th day since the start of EA treatment (Fig. 4). One week after initiation of EA treatment, circumference of the central region of the shank in the affected side decreased to 0.93 times of that of the healthy side (Fig.1, right photo). It is unclear whether this decrease in the circumference was due to muscular atrophy or reduction in edema because of the elastic bandages.

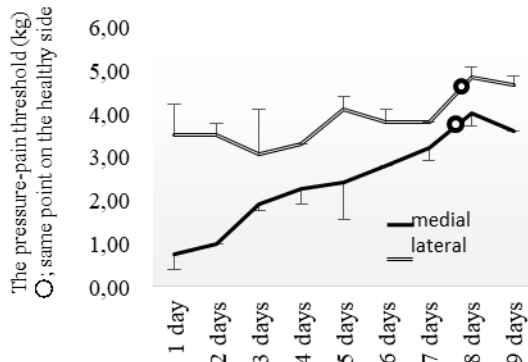


Fig. 4 The pressure-pain threshold in the gastrocnemius after the start of EA treatment

Significant recovery of muscle strength, range of motion, and alleviation of pain was achieved in the first week since the initiation of EA treatment, and allowed the patient's smooth progression to athletic rehabilitation program. The patient resumed light jogging and moderate-intensity cycling exercises when the swelling disappeared, and the isometric muscle strength, ankle range of motion, and pressure-pain threshold of the gastrocnemius muscles were restored to that of the healthy side. At this point, no plyometric weight exercise was performed, and the strength training intensity with limited joint movement was increased gradually. The running speed was increased gradually, ensuring that no pain was experienced, and simple direction change motions (cutting) and step works were resumed 10 days after starting EA treatment. Thereafter, on the 15th day since starting EA treatment, the patient was able to perform sprinting, single leg jumping, step work, and the basic motions required for playing handball. The patient successfully extended handball playtime gradually, with continuing EA treatment before exercise, in combination with RICE treatment after exercise, and intermittent strength training.

Calf muscle strain, also known as *tennis leg* (because of its frequent manifestation in tennis and badminton), is believed to be caused by sudden lateral and anterior-posterior transitions (Miller AP.). Gastrocnemius injury is among the traumatic injuries that require attention in handball, which involves fine foot-works and repetitive jumping/landing. Luig P. reported that traumatic injury involving lower the limb joint ligaments were particularly problematic in women's handball games; moreover, incidence of gastrocnemius muscle injury was demonstrated to increase with age. Non-contact muscle injuries during exercise are mostly caused by eccentric muscle contraction, which is considered to occur during the switching of coordinated movement between agonist and antagonist muscles. Furthermore, muscle atrophy resulting from injury can be explained by a combination of impaired force generation and force transmission due to microstructural damage occurring immediately after the injury, and a decline in the amount of contractile protein, 2 weeks or later, after the injury (Warren GL. et al). Therefore, specialized care in sports medicine is focused on pain suppression with minimal reduction in the morphological and functional levels of injured muscles.

Sakai T. et al. studied the peripheral circulatory dynamics on electro-muscular and electro-nerve stimulations in humans. Both stimulations increased blood flow to the target muscles, core temperature, and deep pain threshold. The magnitude of increment was greater with electro-nerve stimulation. Therefore, EA stimulation in the initial stage of muscle injury may be effective for early recovery from microstructural damage and transmission disorders, and for further reduction of pain. Furthermore, Ikemune S. et al. found that EA stimulation at 10 Hz inhibited inactive muscle atrophy; additionally, many animal studies have reported EA

stimulation to prevent muscle wasting at the molecular level. Although studies on the clinical efficacy of EA stimulation in case of human muscle injury are limited, it is expected to be efficacious in patients with inactive muscle atrophy associated with sports injuries.

This case was diagnosed as a moderate muscle injury based on the symptoms at the time of injury and was expected to require more than 4 weeks to resolve and return to competition level. Because of the combined optimal treatment delivered initially, i.e., acupuncture therapy, physical therapy, and athletic training, the patient recovered favourably and resumed playing in competitions in approximately 3 weeks after the injury. Thereafter, the patient exhibited no signs of recurrence of injury at the same site, and the injury did not impact the high-intensity play required during competition. In sports medicine, because various combinations of therapies and training programs are performed to ensure successful return to competition, it is extremely difficult to evaluate the effect of each modality separately. Furthermore, the course of recovery may differ depending on the degree of injury and individuals. Therefore, in view of the underlying physiological repair mechanisms identified by preliminary studies, we believe that EA therapy for treating muscle injury is likely to be one of the physical therapies that accelerates the resumption to competitions.

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WHAT MAKES YOU WIN? – THE PERCEPTION OF HANDBALL SPECIFIC MATCH SITUATIONS

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Summary

We investigated the handball players' perceived influence of permitted fouls and other handball specific events on the expected overall team-success. Although we found a significant influence of permitted fouls, the influence size of permitted fouls can be seen as quit low, compared to other handball specific events. Furthermore, team-handball can be seen as an exception for the positive-negative asymmetry effect.

Keywords: team-handball, foul, free-throw, positive-negative-asymmetry-effect

Introduction

Team handball is one of the most complex team-sports based on the variety and diversity of the individual as well as team movement structures. Different studies already illustrated individual characteristics as psychological (Silva, 2006), morphological (Srhoj, Marinović, & Rogulj, 2002), and anthropometric (Hermassi, Laudner, & Schwesig, 2019) aspects as performance indicators in team handball. Furthermore, tactical activity has been seen as a crucial feature of sport games, so that several aspects from an offence, defense and goalkeeper perspectives have been considered as performance indicators (Bilge, 2012; Daza, Andrés, & Tarragó, 2017).

Different studies focused already on particular technical-tactical elements in handball as the number of goals and shots from different positions (Srhoj, Rogulj, & Katić, 2001) or collective tactical elements in attack activities (Rogulj, Srhoj, & Srhoj, 2004). Another investigated tactical element in team-handball is the permitted foul, sanctioned by a free-throw. Such fouls are very interesting for tactical analysis, since they play a special role in team-handball, as the defenders are allowed to have body-contact with the opposing attackers to decrease the opponents' likelihood of scoring a goal and to keep an optimal defense position. In a previous study, we investigated if permitted fouls are an effective way to improve the defense quality by reducing the number of goals scored by the opponent (Fasold & Redlich, 2018). However, we found that none of the examined defense strategies was seen as a favorable solution for successful defending, including stopping offensive actions through body contact, avoiding fouls, as well as focusing only on intercepting the ball. In contrast, Brack (2008) weighted permitted fouls as positive in this game effectivity-index. Besides these mixed results, the subjective view of expert coaches suggests to implement a clear defense strategy to increase the potential benefit of the tactical possibility of permitted fouls in team-handball (Brand 2008, Landuré, 2011). However, we argue that probably the detailed subjective view of the involved players, including the comparison of permitted fouls to other handball specific events, might provide an even better insight into to the potential beneficial effect of permitted fouls as a tactical element in team handball. Furthermore, different perspectives, as being in an offense or defense situation, might have an impact on the perception of permitted fouls as well as on the perception of other handball specific events. Through the comparison of different perspectives, one might assume, that players would perceive permitted fouls and other different handball specific events as a disadvantage, when a permitted foul made by the own team is seen as less effective compared to a foul made by the opponent team. This assumption is based on research

by Baumeister and colleagues (2001), who pointed out, that in general, people were biased to the occurrence and avoidance of negative events and experiences in everyday events, major life events (e.g., trauma), close relationship outcomes, social network patterns, interpersonal interactions, and learning processes. This phenomenon is related to the positive-negative asymmetry effect (Taylor, 1991), which is described as "...one of the most basic and far-reaching psychological principles" (Baumeister et al., 2001, p. 362). Besides this, they request to search and identify exceptions as spheres or circumstances in which good events outweigh the bad ones.

Consequently, the first aim of this study is to gain better insight into the potential beneficial effect of permitted fouls as a tactical element in team handball by investigating the players' perceived influence of permitted fouls on the expected overall team-success at the end of a game, by comparing fouls to other handball specific events from an offense and defense perspective. The second aim is to investigate the positive-negative asymmetry effect (Taylor, 1991) in a competitive sports setting, by comparing the influence-sizes of the different handball specific events on the expected overall team-success at the end of a game between an offense and defense perspective.

Methods

We argue that only permitted fouls, which lead to a free-throw, might interrupt the game and therefore can be seen as tactical element. As a consequence we assume that focusing on free-throw events in team-handball, caused by a permitted foul, are the best way to investigate the potential beneficial effect of permitted fouls as a tactical element. In cooperation with three handball professionals¹, six additional handball specific events (goal, assist, 7m-penalty, time suspension, missed shot and technical mistake), which probably influence the expected overall team-success of a game, were selected to be used in this study in addition to the free-throw event. The overall team success of a game is here seen as the final result of a game.

Based on this, we developed a questionnaire to measure the influence of the handball specific events on the expected final result of a game. Here, participants were asked to read a handball specific game event and estimate the effect of this event on their subjective expectation on the final result of a game. In contrast to previous similar studies, in which only one question per event was asked (Moesch, Bäckström, Granér, & Apitzsch, 2014), we tried to represent each event in its diversity and increased the internal reliability of the questionnaire by reframing each handball specific events in three different ways. Hereby the events were phrased from the individual as well as the team perspective (e.g. "your team is in ball-possession and... you or a teammate scores a goal"). However, the interpretative diversity of each event (e.g. if a goal was scored from the corner, or deflected by the opponent), could not be taken into account. Furthermore, the seven events were formulated from an offensive as well as a defensive perspective ("your team is in ball possession" vs. "the opponent team is in ball possession"). The participants evaluated the influence of the handball specific events on the expected final result of a game on a 7-point Likert-scale (from -3 = this event strongly decreases the likelihood of winning the game, up to 3 = this event strongly increases the likelihood of winning the game).

The questionnaire was sent to the coaches or team-officials of the participating teams via post or e-mail. Participants completed the questionnaire online or in the respective training facilities of their handball club. In the introduction-part of the questionnaire, the participants

¹ With coaching experience of more than fifteen years

were informed about the aim of the questionnaire and that the data would be treated confidentially.

A total of 108 female German speaking participants ($M_{age} = 25.33$, $SD = 7.69$; these descriptives are based on data from 84 participants, since 24 participants did not complete the questionnaire and lead to missing data about age, experience and playing position. However the remaining data were used for the analysis) took part in the study.

Results

Means, standard deviations and Cronbach's Alpha of the single events are shown in table 1. All events show a satisfying reliability. The highest positive influence on the expected final result of a game was found for the event "goal" after the own team scored ($M = 1.98$, $SD = 0.87$) and the highest expected negative influence on the expected final result of a game was found for the event "goal" after the opponent scored ($M = -1.66$; $SD = 1.08$). Cronbach's Alpha coefficients displayed a good internal consistency for all events ($M = .82$; $SD = .06$). Related to the neutral baseline, which is defined as "0" on the Likert-scale, a Wilcoxon signed-rank tests showed a significant influence of all handball specific events on the expected final result of a game (table 1). More specifically, we used Wilcoxon signed-rank tests to compare the influence sizes, described as the intensity to which an event influences the match outcome, of the free-throw event and the respective additional events from the offensive as well as the defensive perspective. The influence-sizes for technical mistakes and missed shots were transformed by multiplication with "-1" to get all effect-sizes for the analysis in the same dimension. The results reveal, that free-throws from the defensive perspective have the significantly lowest influence on the expected final result of a game compared to all other events from the defensive perspective as penalty ($Z = -7.946$, $p = .001$), technical mistake ($Z = -6.836$, $p = .001$), goal ($Z = -7.829$, $p = .001$), missed shot ($Z = -4.528$, $p = .001$), time-suspension ($Z = -7.946$, $p = 001$) and assist ($Z = -7.619$, $p = .001$). Similar, free-throws from the offensive perspective have been found to have the significantly lowest influence on the expected final result of a game compared to all other events from the offensive perspective, including penalty ($Z = -8.108$, $p = .001$), technical mistake ($Z = -6.059$, $p = .001$), goal ($Z = -8.508$, $p = .001$), missed shot ($Z = -3.456$, $p = .001$), time-suspension ($Z = -7.910$, $p = 001$) and assist ($Z = -8.248$, $p = .001$).

Table 1: Descriptive statistics, Cronbachs alpha coefficients and Results of Wilcoxon Signed Ranks Test, comparing the influence-size to the baseline, for the investigated handball specific events (n= 108).

Variable	Mean	SD	α	Wilcoxon Signed Ranks Test	
				Z	significance (2 tailed)
<u>Offense</u>					
Opponents time-suspension	1.66	0.82	.790	-6.304 ^b	.001
missed shot	-1.00	1.00	.725	-6.022 ^a	.001
technical mistake	-1.21	0.96	.842	-6.222 ^a	.001
goal	1.98	0.87	.854	-6.418 ^b	.001
assist	1.56	0.81	.792	-6.413 ^b	.001
free-throw	0.66	0.90	.924	-4.646 ^b	.001
7m penalty	1.62	0.93	.865	-6.314 ^b	.001
<u>Defense</u>					
own team time-suspension	-1.50	0.88	.865	-6.156 ^a	.001
missed shot	1.02	0.94	.761	-5.198 ^b	.001
technical mistake	1.27	0.77	.656	-6.074 ^b	.001
goal	-1.66	1.08	.829	-6.138 ^a	.001
assist	-1.33	0.96	.836	-6.304 ^a	.001
free-throw	-0.56	0.83	.820	-4.626 ^a	.001
7m penalty	-1.37	1.01	.879	-5.027 ^a	.001

Note: *SD* = standard deviation; α = Cronbachs alpha; ^a = based on negative ranking; ^b = based on positive ranking.

Furthermore, Wilcoxon signed-rank tests were conducted to test the difference in influence-size, between the perception of events from the offensive and defensive perspective. Hereby, the results from the defense perspective were transformed by multiplying with “-1”, to get the effect-sizes for the comparison in the same dimension and therefore being able to compare the event’s influence sizes from the different perspectives. The results revealed significant distinctions of the influence-size between the offensive and defensive perspectives for the events goal ($Z = -4.073, p = .001$), assist ($Z = -2.068, p = .039$) and penalty ($Z = -2.988, p = .003$) (figure 1). The influence size from the offensive perspective is hereby stronger than the influence size from the defensive perspective.

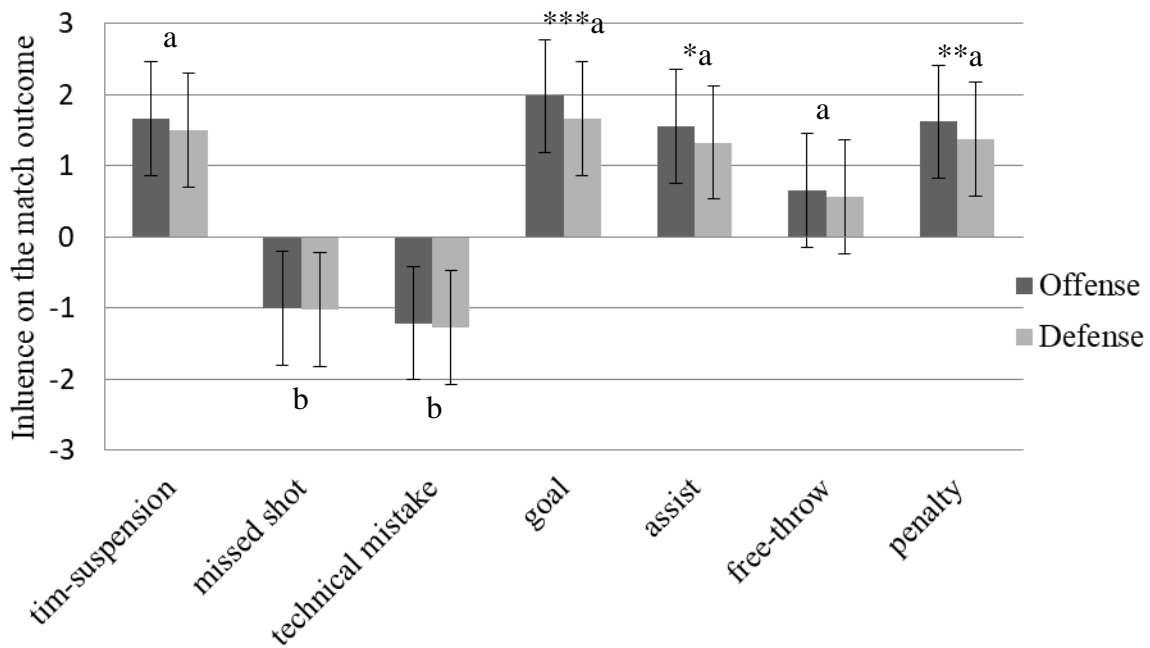


Figure 1. Results of the Wilcoxon Signed Ranks Test for comparison of the influence-size between events from the offensive and defensive perspective (the defensive-values were, for comparison reasons, multiplied with “-1”)

Note. * = significant difference for $p < .05$; ** = significant difference for $p < .01$; *** = significant difference for $p < .001$; a = based on positive ranking; b = based on negative ranking.

In general it can be seen, that the events are rated contrary to each other depending on the offensive or defensive point of view. Events with a negative influence on the likelihood of winning a match from the defensive perspective are related with a positive influence on the likelihood of winning a match from the offensive perspective. The same mirror effect can be seen for events with a positive influence from the defensive perspective.

Discussion

Based on the mixed results about the usefulness of permitted fouls as a tactical element for efficient and successful defensive strategies in team handball, we decided to investigate the players’ perception of permitted fouls, on the expected overall team-success at the end of a game. Similar to Brack (2008), our data propose a positive influence of permitted fouls, leading to free-throws, on the expected final result of a game. However, interpreting the influence size of fouls and therefore free-throws in the context of other handball specific events, our results showed that the influence of free-throws on the expected final result of a game was perceived as the significantly least influential event. One might question, if the players probably do not care about fouls and free-throws, but we assume that these results might be explained by the binary view on fouls; on one hand it might be that the defense interrupts the attacking concept, but fails to get possession of the ball, on the other hand the offense failed to create a good scoring

position, but is still in ball possession and can has time to create another attack. As a result, both viewpoints might cancel each other out, leading to the small influence size for free-throws on the expected final result of a game. This aspect might support the findings of our previous study, where we did not find an effect of fouls on the match outcome (Fasold & Redlich, 2018), because the influence size of fouls, and therefore free-throws, is probably too small to be detected, compared to other handball specific events.

Furthermore, taking the influence sizes of all handball specific events on the overall team-success at the end of a game into account, we found that the influence size differs for some handball specific events between the offensive and the defensive perspective. Hereby it is interesting to notice, that players perceive such differences always for their benefit (e.g. the influence-size of a goal scored by the own team is perceived higher, than a goal scored by the opponent team). This difference leads to the assumption that the athletes might in some cases be biased towards own-team-supportive-events, especially since the expected contrary bias towards opponent-team-supportive-events could not be found. This is surprising, as it seems to be in contrast to the general bias towards the occurrence and avoidance of negative events and experiences in everyday events, and therefore the area of competitive sports can be seen as an exception for the positive-negative asymmetry effect (Taylor, 1991). One explanation might be that in sport the goal of winning cannot be reached by avoiding negative situations, since it is difficult to win only by defending. Therefore the aim in competitive sport is to create positive situations, to score goals and to win. Consequently, in the area of competitive sport the positive-negative asymmetry effect will be converted from a phenomenon with a prevention focus on negative aspects to a positivity bias phenomenon with a supportive focus on positive aspects. Consequently, we assume that this positivity bias phenomenon can also be found in other areas of competitive sports.

Conclusion

Summing up, we found that permitted fouls leading to free-throws have a significant influence on the expected overall team-success at the end of a game, but that the influence size can be seen as quit low, compared to other handball specific events. These results help to create a better understanding of the potential beneficial effect of permitted fouls as a tactical element in team handball. However, so far, the practical relevance of permitted fouls should probably be seen as a minor tactical element, compared to other tactical elements. However, different defensive-systems, new perspectives from different performance levels and playing positions should be taken into account in future research, prior to integrating permitted fouls as a tactical element in training sessions and tactical discussions.

Besides this, we found an exception for the positive-negative asymmetry effect (Taylor, 1991) in team-handball, named as the positivity-bias-phenomenon, where athletes perceive and interpret handball specific events significantly to their advantage. Here, an expansion of research on this phenomenon in other sports could help to declare this phenomenon and bring it in context with the super ordinate positive-negative asymmetry effect.

APPLICATION OF ONE-HANDED CATCHES IN ELITE MEN'S TEAM HANDBALL

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Summary

The present study examined the application of one-handed catches in international handball games. Twelve different teams were video analyzed throughout 24 matches. The OHCs were categorized in five categories. Significant differences between the categories itself and some teams were found for the total number of OHCs, for low intense actions and for fast break actions. The average application of OHCs per game was 94.73 ± 30.99 .

Keywords: one-handed catch – handball – game analysis – technique – resin

Introduction

Technical, tactical, psychological/social and physical characteristics of the players determine the level of performance in modern team handball (Michalsik, Aagaard, & Madsen, 2013). Recent evidence suggests that the grip and size of a ball have an effect on the throwing movement pattern and throwing velocity (Fasold et al., 2019). This consequently influences the way the ball is played. In addition, “[...] the use of different types of resin [make] it easier to get a good grip on the ball [...]”, which results in new throwing and catching techniques (Tanggaard, Laursen, & Szulevicz, 2016). One of these techniques is the one-handed catch (OHC). Späte and Schubert define the OHC as a dynamic and fast variation of a catch with an elevated risk factor. The OHC facilitates faster game actions with a surprise effect. Commonly, it is used in counterattacks, pivot catches and in a positional attack to earn a time advantage (Späte, Schubert, 2010). Nowadays, this technique is also part of the youth training concept of the German Handball Federation (Brand & Deutscher Handballbund, 2009; Kromer, 2015).

However, most of the handball matches are analyzed in a static way, this is with the purpose to get a final data set that describes what has happened during the match. The match process and the performance context are not taken into account (Prieto, Gómez, & Sampaio, 2015). Nevertheless, only a few studies focus on technical aspects like the application of the OHC, on the other hand, in how often and in which situations the OHC is used, have not been assessed yet. Based on the definition and the forecasted actions, where the OHC is used, it could be predicted that the application of OHC will be higher in high intense actions than in low intense actions. Furthermore, we expect differences in the amount of OHCs between different countries.

Methods

Twelve different teams were analyzed throughout 24 matches of the Men's world cup of 2019 by three independent handball experts (Coaching License B-Level). The quantitative game observation focusing on OHCs was divided in five movement categories: 1. Low intense actions (standing still, walking, backwards running) including sideways movements with orientation away from the goal. 2. High intense actions, which are characterized by forward movements i.e. (fast-) running or sprinting with the orientation towards the goal after accepting the ball and with

a following one-on-one situation or a change of direction. If one of those 3 characteristics had not been available, the OHC was categorized as low intense. 3. Fast break actions including the easy, direct and extended fast breaks and actions after a fast throw-off. 4. Pivot catches (OHCs near to the 6m line) and 5. Interceptions. Although a few OHCs could not be counted, this was because of slow-motion sections in the video data during the game. Nonetheless, for the data was examined by conducting an Analysis of Variance “ANOVA”, while for the post-hoc analysis a Bonferroni test was employed.

Results

In total, 4547 OHCs were counted. The average application of OHCs per game was 94.73 ± 30.99 . On average 58.48 ± 21.76 OHCs were used in low intense actions, 22.40 ± 9.80 in high intense actions, 7.10 ± 5.11 in fast break actions, 3.52 ± 1.83 in pivot catches, and 3.23 ± 2.19 in interceptions.

Germany (n= 5) made 546 OHCs with an average application of 109.20 ± 15.37 per game. Further, Germany showed an average of 70.40 ± 6.66 OHCs in low intense actions, 22.20 ± 10.76 in high intense actions, 8.20 ± 4.49 in fast break actions, 4.20 ± 4.49 in pivot catches and 4.20 ± 1.30 in interceptions per game.

While Denmark (n= 5) conducted 412 OHCs with an average application of 82.40 ± 16.92 per game. In the different categories Denmark had an average of 51.00 ± 13.67 OHCs in low intense actions, 17.60 ± 5.41 in high intense actions, 6.40 ± 4.62 in fast break actions, 4.80 ± 2.28 in pivot catches and 2.60 ± 1.95 in interceptions per game.

Norway (n= 5) showed 428 OHCs (85.60 ± 16.44 per game, divided in 50.40 ± 14.67 low intense actions, 20.80 ± 5.26 high intense actions, 8.20 ± 3.70 fast break actions, 3.20 ± 2.59 pivot catches and 3.00 ± 1.58 interceptions per game) and France (n= 5) showed 287 OHCs (57.40 ± 8.64 per game, divided in 31.80 ± 7.19 low intense actions, 15.60 ± 3.21 high intense actions, 3.80 ± 2.05 fast break actions, 1.80 ± 1.30 pivot catches and 4.40 ± 2.79 in interceptions per game).

Divided in the different categories Spain (n= 4) showed an average of 74.25 ± 9.54 OHCs in low intense actions, 31.25 ± 9.91 in high intense actions, 6.00 ± 2.71 in fast break actions, 3.75 ± 2.06 in pivot catches and 4.75 ± 1.71 in interceptions per game and made 480 OHCs overall.

On one hand, Croatia (n= 4) and Egypt (n= 4) did an average of 68.50 ± 32.03 and 96.25 ± 13.77 in low intense actions, 22.50 ± 15.59 and 35.00 ± 7.16 in high intense actions, 3.50 ± 2.52 and 13.25 ± 7.50 in fast break actions, 3.50 ± 1.29 and 3.75 ± 2.22 in pivot catches and 0.50 ± 0.58 and 3.75 ± 1.89 in interceptions per game. Overall Croatia conducted 222 and Egypt 608 OHCs.

On the other hand, Sweden (n= 4) did an average of 46.00 ± 16.21 in low intense actions, 23.50 ± 3.79 in high intense actions, 14.75 ± 4.92 in fast break actions, 4.00 ± 2.45 in pivot catches, 3.75 ± 2.22 in interceptions per game and showed 368 OHCs overall.

As well as, Iceland, Brazil, Hungary and Tunisia played 3 games with an average application of 73.33 ± 23.84 (Iceland), 82.33 ± 18.15 (Brazil), 14.00 ± 17.15 (Hungary) and 111.67 ± 4.99 (Tunisia), per game. In low intense actions Iceland performed an average of 47.33 ± 13.01 , in high intense actions 17.33 ± 16.62 , in fast beak actions 3.67 ± 2.89 , in pivot catches 2.33 ± 1.53 and in interceptions 2.67 ± 0.58 , per game and made 220 OHCs overall.

In addition, Brazil made 247 OHCs and the average number of OHCs per game in the categories was as follows: 55.33 ± 14.36 in low intense actions, 17.00 ± 13.53 in high intense actions, 3.33 ± 3.51 in fast break actions, 2.67 ± 0.58 in pivot catches and 4.00 ± 2.00 in interceptions per game.

Hungary and Tunisia showed overall 222 and 335 OHCs and a number of 43.33 ± 17.62 , 70.33 ± 5.86 in low intense actions, 21.00 ± 6.08 , 26.33 ± 4.16 in high intense actions, 4.33 ± 2.08 , 8.00 ± 4.58 in fast beak actions, 4.67 ± 0.58 , 3.33 ± 1.15 in pivot catches and 0.67 ± 0.58 , 3.67 ± 1.15 in interceptions (Fig. 2, 3, 4 for total number of OHC, low intense actions and fast break actions).

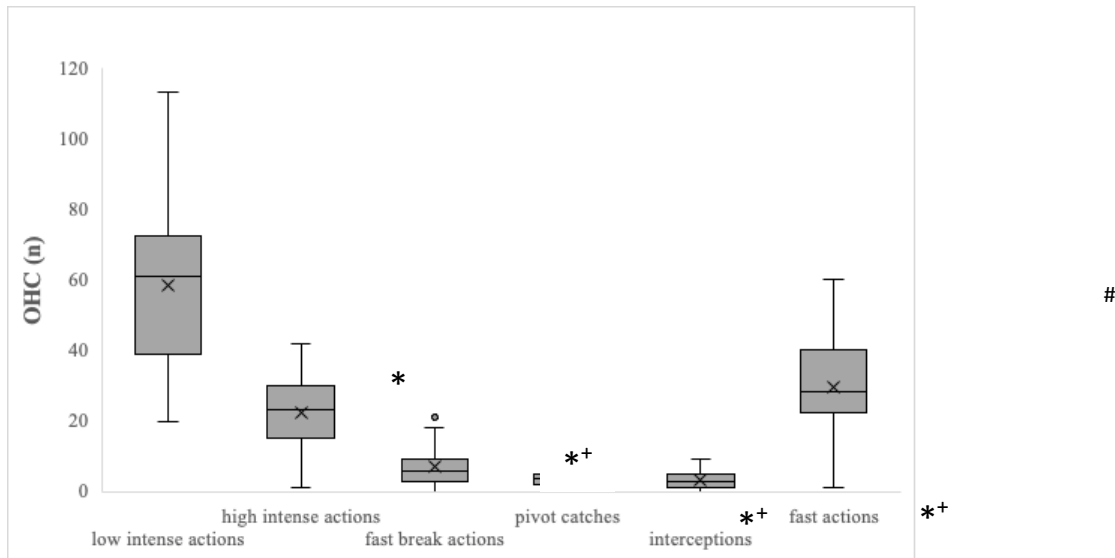


Figure 1: Number of OHCs for the categories; *= significantly less OHCs compared to low intense actions; += significantly less OHCs compared to high intense actions; #= significantly less OHCs compared to low intense actions ($p < 0.05$).

Significant differences were observed between the different categories of OHCs. ($F(4,235) = 218.66$, $p < 0.05$). Applying a post-hoc Bonferroni test significantly more OHCs were conducted in low intense actions than in all other categories ($p < 0.05$). Moreover, significantly more OHCs were performed in high intense actions compared to pivot catches, fast break actions and interceptions ($p < 0.05$). Post-hoc t-test was conducted for low intense actions ($M = 58.48$, $SD = 21.76$) compared to fast actions (high intense actions + fast break actions; $M = 29.50$, $SD = 12.46$) and it was found a significantly higher number of OHCs in low intense actions than in fast actions ($t(94) = 8.01$, $p < 0.05$) (Fig. 1).

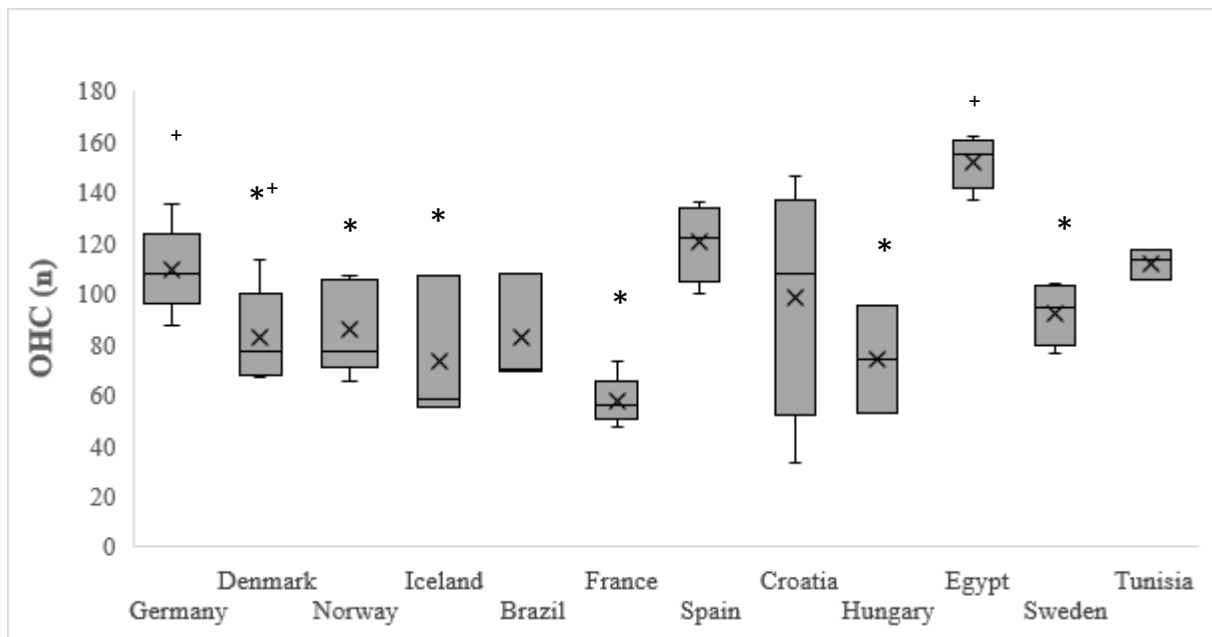


Figure 2: Number of OHCs per game: *= significantly less OHCs compared to Egypt; += significantly more OHCs compared to France ($p < 0.05$).

Moreover, significant differences were observed for the total number of OHCs between the teams ($F(11,36) = 5.84$, $p < 0.001$). Applying a Bonferroni post-hoc test, it was found that Egypt performed significantly more OHCs in total compared to Sweden, Hungary, France, Iceland, Norway and Denmark ($p < 0.05$). Furthermore, France applied significantly less OHCs in total than Germany, Denmark and Egypt ($p < 0.05$) (Fig. 2).

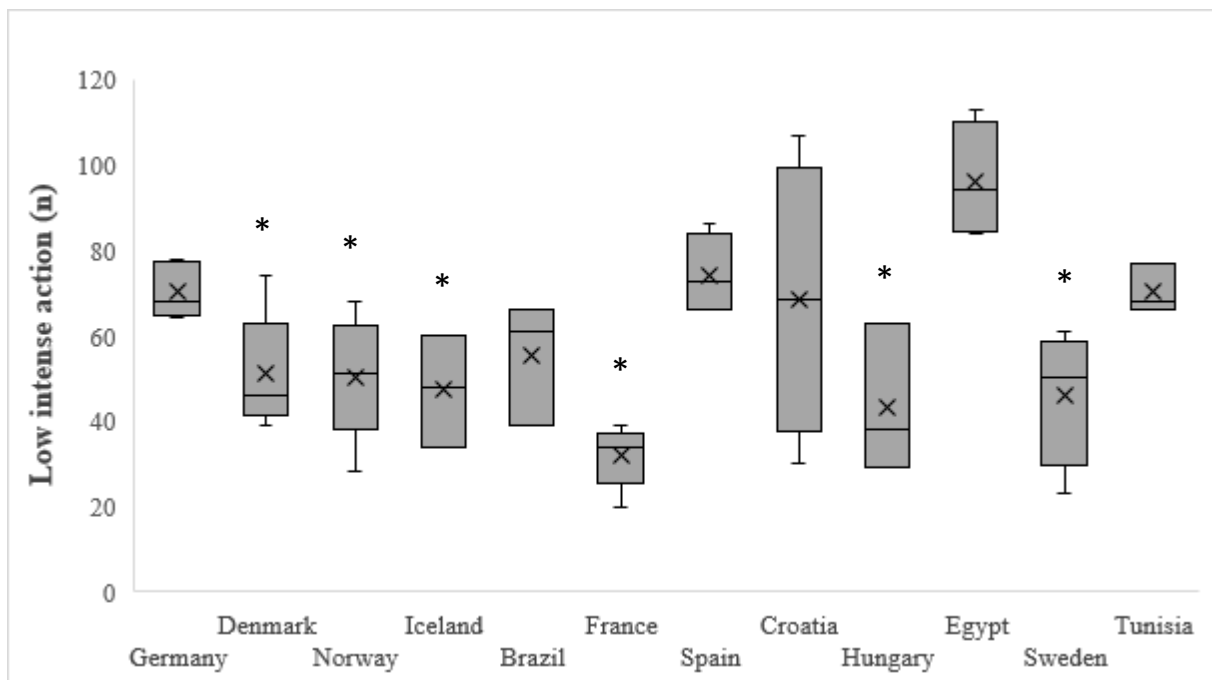


Figure 3: Number of OHCs in low intense actions for the different teams; *= significantly less OHCs compared to Egypt ($p < 0.05$)

Further, in low intense actions significant differences were observed between teams ($F(11,36) = 5.67, p < 0.05$). A Bonferroni post-hoc test showed that Egypt perform significantly more OHCs in low intense actions compared to Sweden, Hungary, France, Iceland, Norway and Denmark ($p < 0.05$) (Fig. 3).

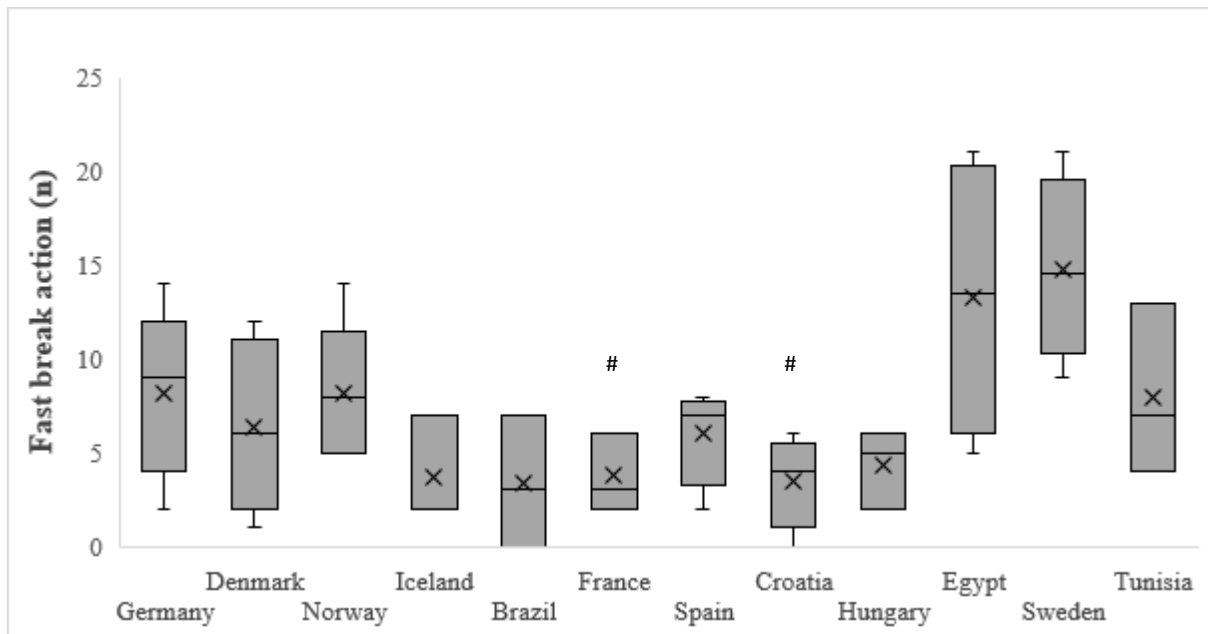


Figure 4: Number of OHCs in fast break actions for the different teams; # = significantly less OHCs in fast break actions compared to Sweden ($p < 0.05$).

Moreover, a significant difference was found for the number of fast break actions between the countries ($F(11,36) = 3.29, p < 0.05$). Bonferroni adjusted post-hoc test showed for fast break actions that Sweden performed significantly more OHCs than France and Croatia ($p < 0.05$) (Fig. 4). No other significant differences were found for high intense actions ($F(11,36) = 1.68, p = 0.12$), pivot catches ($F(11,36) = 1.02, p = 0.45$) and interceptions ($F(11,36) = 1.74, p = 0.10$).

Discussion

A higher number of OHCs was predicted for high intense actions. In contrast to this assumption the results showed a highest amount of OHCs in low intense actions with a significantly higher amount compared to the other categories. In fact, this could be explained by missing multiple pressure conditions for example precision pressure and time pressure, as well as, situational pressure conditions. These low-pressure conditions could induce the players to an easier application of OHCs. Furthermore, the application of the OHC could depend on the individual technical level and the individual preferences of the players, especially in low intense actions.

Another possible reason could be that a good pass is needed to perform an OHC, which also could be reduced in high intense actions. According to Michalsik's study, the male handball players spend 76.40 ± 10.40 % of the total effective playing time with standing or walking, which could have an influence on the data (Michalsik, Aagaard, & Madsen, 2013). In addition, the handball game might be at a point where it is not possible to generate a new technique like the OHC in high intense actions because of body contact, game velocity and the resulting higher

risk of losing the ball. Maybe the OHC is too risky and can therefore not be used frequently in high intense actions.

For this study, it was predicted that the amount of OHCs could vary between the countries. Indeed, the results demonstrated significant differences in the total amount of OHCs (e.g. Egypt to Sweden and Hungary), the amount of OHCs in low intense actions (e.g. Egypt to Sweden and Hungary) and fast break actions (e.g. Sweden to France and Croatia) between some teams. Based on these results, the assumption that there were differences between the countries was confirmed, which could be explained by different teaching methods and the game philosophy used in the countries itself. Furthermore, the coach's opinion could play a crucial role whether the players execute the OHC or not.

To conclude, the study shows the highest amount of OHCs in low intense actions and some differences in the application of the OHC between the countries.

Future investigations could focus on the men's youth world championship, as well, to compare these findings to the results of the men's world cup of 2019 being analyzed in this study. Another interesting and potential study could be the comparison to the female teams. Moreover, a dynamic match analysis could help to get further information to consider in which performance context, situations and chronological and sequential order the OHC is used (Prieto, Gómez & Sampaio, 2015). Finally, a qualitative survey could reveal on to what extent the OHC is integrated and coached explicitly or implicitly in the training process of different countries. This investigation could challenge or confirmed our assumption regarding the application of OHCs in different training situations and between countries.

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QUANTIFICATION OF MONOTONY, WEEKLY LOAD AND STRAIN DURING THE ENTIRE COMPETITIVE PERIOD IN SEMI-PROFESSIONAL FEMALE HANDBALL

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Summary

The aim of this research is to describe the training load indices (weekly load, strain), acute and chronic monotony, acute:chronic workload ratio (A:CWR) and to find out alteration during the competitive period in semi-professional female handball. Twelve field players have been monitored using the session rating of perceived exertion (sRPE). Monotony, strain and A:CWR are highly related to the volume of training. RPE is a simple and effective method of monitoring internal loads in handball.

Keywords: session-RPE, monitoring, internal training load

Introduction

The fundamental goal of coaching is to optimise sports performance of athletes, particularly during the long-term competitive period in handball. In order to optimize a handball player's adaptation to the training program, coaches must initially quantify a player's response stress (McGuigan, 2017). It is a very difficult task to prescribe correct training loads for a handball team, because of different physical fitness and skills of athletes (Michalsik, 2015). This task is more difficult during the long-term competitive period, when weekly games require the players to be in their best condition to compete (Manchado et al., 2018). Recovery interventions should be periodized to influence acute and chronic training adaptation and performance (Mujika et al., 2018). The ability to control and monitor internal training load is a very important aspect of effective coaching (Fullarton, Benton, 2014).

Nowadays the entire competitive season in handball lasts 7–9 months. The problem is how to manage detraining and retraining of handball players fitness occurring during the very long period. Scientists and coaches monitor training loads using multidisciplinary approaches (Bourdon et al., 2017; McGuigan, 2017). One of the valid methods is measuring internal training load (ITL), which includes both the physiological and psychological strain imposed on the athlete (Halson, 2014; Laursen, Buchheit, 2019; Saw et al., 2016). Perception of effort is a common tool used to monitor athlete training loads in order to assess training intensity and volume (Borg & Noble, 1974; Haddad et al., 2014; Thornton et al., 2016). Rating of perceived exertion (RPE), and the session-RPE (sRPE) method could be considered a valuable training tool that can be used practically by coaches to monitor and control the internal playing load of their athletes, also aiding to design periodisation strategies for monitoring athletes' responses to training and preventing overtraining in team sports (Buchheit, 2019; Fullarton, Benton, 2015; Hulin et al., 2016). Researchers (Bresciani, 2010; Eston, 2012; Foster, 1998; Foster et al., 2001; Haddad et al., 2014; McGuigan, 2017) suggest that RPE may be a more reliable measure when both anaerobic and aerobic systems are appreciably activated, especially in such sport as handball (Buchheit, 2019).

Permanent monitoring of monotony, weekly training loads and strain could be useful to evaluate detraining process, to manage retraining fitness of players during the long competitive season, and to prevent injuries (Gabbett, 2016; McGuigan, 2017; Thornton et al., 2016). Little is known about alteration of internal loads (IL) in female handball during the competitive period.

technical and tactical skills) residual training effects occur in different biomotor abilities after the cessation of training (Mujika, Padilla, 2003; Mujika et al. 2018). For this reason the long-lasting competitive period (37 weeks) was divided into 12 mesocycles (Figure 1) consisting of competitive microcycles and followed by retraining microcycles in the following sequence: 1) 3–1; 2) 1–1; 3) 2–1; 4) 2–1; 5) 1–1; 6) 1–3; 7) 3–1; 8) 1–1; 9) 2–1; 10) 2–1; 11) 2–1; 12) 4–0. Competitive microcycles have been applied according to the matches schedule, the level of competition and the mastery of opponents. Retraining microcycles program have been applied relying on the handball experts (Buchheit, 2019; Granados et al., 2008; Manchado et al., 2018; Marques et al., 2006; Michalsik, 2015; Skarbalius, 2010). The structure of training program (in percentage) of the competitive period lasting 37 weeks was applied as follows: warm-up – 26.3%; recovery – 10.1%; integral – 19.1%; tactical – 18.8%; technical – 11.1%; physical – 11.4%; theoretical – 3.2%. Such structure of training program is different from Buchheit (2019) because of a limited number of social factors for adequate training of professional teams. Nevertheless, this semi-professional team has reached 1/8 final of the European Challenge Cup, has won Lithuanian championship and Cup, and has taken the third place in the Baltic Handball League. Sports results of the team allow suggesting that it would be more appreciated to apply the detailed structure of the content of the training program.

Training load indices, monotony, A:CWR. During the 37-week of the competitive period lasting from September to the first week of June, the players were involved in the training process of 17065 minutes in total, but TL_{minutes} (Figure 2) altered week by week 462.4 ± 104 minutes (Table 1). The highest training load (630 minutes) was applied in the beginning of March (the 25th microcycle) when the team participated in the Baltic League competition, the lowest one was during the 17th retraining microcycle because of short holiday in the winter season (Christmas and New Year). The values of WTL (3341.7 ± 733.6 AU) and S (4858.8 ± 1778.9 AU) have altered similar to TL_{minutes} . The highest value of WTL was during the 19th microcycle (4477) at the end of January the same as S (9596 AU). According to the value of TL_{minutes} , the lowest values of WTL (2095 AU) and S (3090 AU) were during the 17th retraining microcycle.

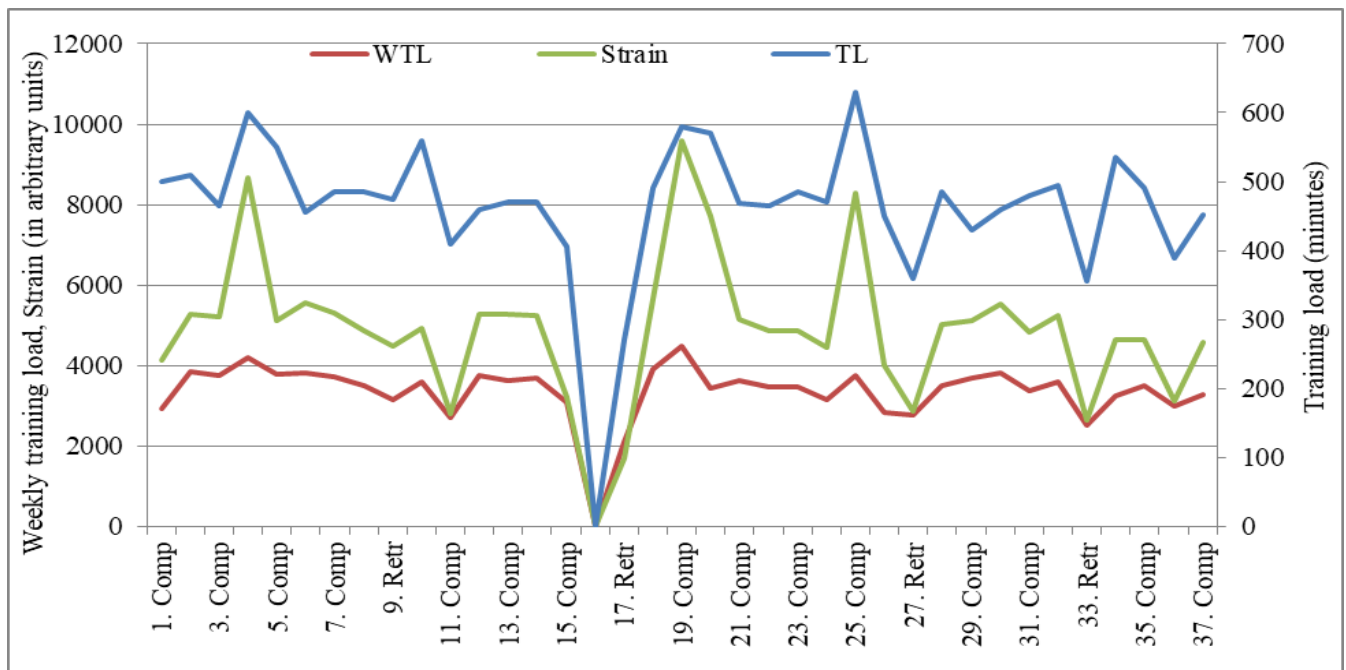


Figure 1. Training load, weekly training load and strain during competition period in semi-professional female handball

Features of microcycles. In spite of the fact, that no significant differences have been found between mixed, competitive or retraining microcycles in $TL_{minutes}$, WTL and S indices, the matches played during the competitive microcycles had a greater impact on TIL indices of semi-professional handball players if compared to retraining microcycles. This is in contrast to the suggestion of Mujika and Padila (2003) that strain can be modified by reducing the training volume without a negative impact on athlete's performance. Research findings allow considering that semi-professional handball players were not fit enough because of the amateur status and through social factors. That's why the retraining microcycles have had a double task – not only for retraining, but also for recovery as well. The study has shown that WTL and S indices of semi-professional handball players were higher compared with professional rugby players (Thornton et al., 2016), but lower than those of Australian National Rugby League (Fullarton, Benton, 2015). Such findings suggest that the results of the current studies are specific to the cohort of recruited athletes.

Monotony ($M_{acute} - 1.39 \pm 0.39$; $M_{chronic} - 1.38 \pm 0.27$ AU), A:CWR (1.01 ± 0.28 AU) has varied during the competitive period similar to the indices of $TL_{minutes}$, WTL and S (Figure 3). The highest M_{acute} was in the 20th competitive microcycle (2.25 AU) and during the 25th competitive microcycle (2.21 AU). M_{acute} was higher than $M_{chronic}$, and than A:CWR nearly the entire period. Hulin and co-authors (2016) suggest that moderate A:SWR combined with higher $M_{chronic}$ load has reduced the risk of injuries. Such model of the training program applied in semi-professional female handball team and the model of alteration indices of M_{acute} , $M_{chronic}$, A:SWR during the competitive period allowed preventing sports injuries (Gabbet, 2016; Hulin et al., 2016).

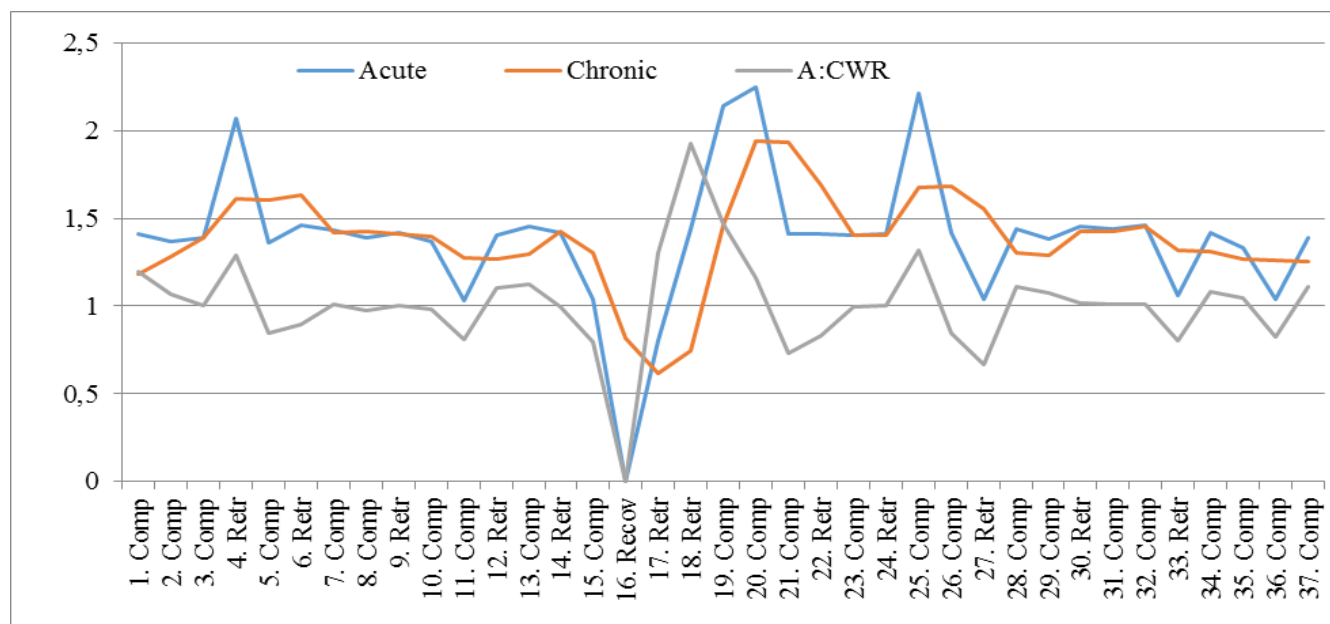


Figure 3. Monotony over the competitive period in semi-professional female handball

Relationship between indices. There was a strong, very strong or near-perfect correlation between TL, WTL and S indices established (Table 1). The correlation analysis revealed different relationship between indices. The strongest relationship was established between TL, WTL and S indices when the training program was applied in retraining microcycles, the lowest one – in the competitive microcycles and moderate – in mixed microcycles (competitive and retraining). Such relationship shows that the proper training program was applied during the

entire competitive period (Buchheit, 2019; Granados et al., 2008; Skarbalius, 2010). The lesser relationship between load indices during the competitive microcycles might occur because of the different number of games played, different time played by the players, and different opponents that have had different effect on the internal loads of players.

Table 1. Values and relation between the load indices in different types of microcycles

Microcycles	Average (SD)				Pearson correlation	
	TL _{minutes}	WTL	S	TL-WTL	TL-S	WTL-S
Mixed	462.4(104)	3341.8(733.6)	4858.8(1778.9)	0.888; p<0.01	0.846; p<0.01	0.832; p<0.001
Competitive	490.8(57.9)	3471.2(380.8)	5119.2(1520.1)	0.574; p<0.01	0.802; p<0.01	0.774; p<0.01
Retraining	442.2(82.6)	3361.4(637)	4742.7(1793,5)	0.896; p .001	0.956; p<0.001	0.937; p<0.001

Monotony_{acute} has depended on TL_{minutes} (r=0.904) and WTL (r=0.846) (Table 2). Monotony_{acute} has had nearly perfect relationship (r=0.952) with strain. Such kind of relationship allows suggesting that different sports, teams, and load monitoring systems will have different relationships between trainings (Lazarus et al., 2017). Research findings allow suggesting that coaches can use the index (TL_{minutes}) for practical training monitoring. On the other hand, a greater number of training sessions for semi-professional female handball players may be associated with an increased risk of injuries (Hulin et al., 2016; Thornton et al., 2016).

Table 2. Relationship between indices during competitive period (Pearson correlation)

	TL _{min}	WTL	Strain	M _{acute}	M _{chronic}	A:CWR
TL _{minutes}	1					
WTL	0.888	1				
Strain	0.845	0.832	1			
M _{acute}	0.904	0.807	0.952	1		
M _{chronic}	0.554	0.459	0.533	0.605	1	
A:CWR	0.646	0.657	0.632	0.655	-0.139	1

Conclusions

RPE is a simple and practical method for monitoring the internal load in handball. To the best of our knowledge, this is the first research carried out in semi-professional female handball. Such kind of monitoring allowed understanding players' responses to their training program, the need for recovery or retraining in order to minimize the risk of non-functional overreaching during the long competitive period and to prevent injuries. The results of the current study are specific to the cohort of recruited athletes. Based on the data collected in this research, the monotony, weekly training load, and strain could be used when planning a season.

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THE EFFECT OF PLYOMETRIC TRAINING ON ANTERIOR CRUCIATE LIGAMENT INJURY PREVENTION AND LEG MUSCLE STRENGTH IN FEMALE JUNIOR HANDBALL PLAYERS

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Summary

The purpose of this study was to investigate the effect of plyometric training on ACL injury prevention and leg muscle strength in female junior handball players. As a result of 12 weeks of plyometric training, the subject's hamstrings strength was enhanced and H/Q strength ratios and eccentric knee extension muscle strength were all improved.

Keywords: handball, plyometric training, ACL, injury prevention, leg muscle strength

Introduction

Anterior cruciate ligament (ACL) injuries are a problem in many team sports, particularly among women (Engstrom et al. 1991, Lindenfeld et al. 1994, Hippe et al. 1993). The risk of rupturing an ACL is five times higher among women than among men, and the gender difference is even higher at the elite level than in lower divisions. Unfortunately, with a reported incidence as high as 1.6 injuries per 1,000 player-hours for elite female players during matches, handball is no exception (Myklebust et al. 1997, 1998). This figure is at least as high as those reported from other team sports (Arendt & Dick. 1995). A predominant theme arising from the literature is that of strength imbalances between the hamstrings and quadriceps muscles (H/Q), known as the H/Q strength ratio, which is often attributed to deficiencies or weaknesses in the hamstring muscles (Ettlinger et al. 1995, Hewett et al. 1996, Huston & Wojtys. 1996). Because these muscle groups serve as the primary functional stabilizers of the knee, an improper balance or deficient ratio predisposes the ACL to injurious forces.

Plyometrics training is often used in handball, which is based upon increasing the rate of force development and stretch shortening cycles during different movements. Plyometric training has been demonstrated to be effective in improving physical performance (Roland et al. 2013). However, more recent investigations have been focused on the role of plyometrics in injury

prevention (Lim et al. 2009, Vescovi & Vanheest. 2010). Hewett et al. (1996) observed decreased impact forces at the knee and increased hamstrings strength in female athletes participating in a plyometric training program. Kavin & Angela. (2011) indicate that a plyometric training program can increase hamstrings strength while maintaining quadriceps strength, thereby improving the H/Q strength ratio.

Plyometric training programs have been implemented in ACL injury prevention programs. However, there are few studies on the effect of plyometric training on leg muscle strength in young female handball players. The objective of this study was to investigate the effect of plyometric training on ACL injury prevention and leg muscle strength in female junior handball players.

Method

Subjects:

The subjects were 12 female junior handball players aged 15 to 17 years who were members of teams that participated in the Kyusyu High School Handball Championships. The participants' mean age, height, weight and body fat, were 16.7 ± 0.5 years, 160.7 ± 4.1 cm, 53.5 ± 4.4 kg and $18.3 \pm 1.3\%$, respectively (presented as mean \pm standard deviation [SD]). All subjects have been performing organized handball training for at least 2 years (average, 2.7 years) and have regularly trained 5–7 times per week. 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.

Procedures (testing protocol):

This study sought to investigate the effects of 12 weeks of plyometric training on leg muscle strength. The training intervention consisted of a plyometric training program, performed 2 times a week for a total of 12 weeks. Participants completed tests for isokinetic strength of knee joint flexors and extensors before the training intervention started (pretests) and after the last training intervention (posttests).

Isokinetic Strength Measurements:

Subjects were evaluated using a Biodex Isokinetic Dynamometer 3 System (Biodex medical Inc, NY, USA) with gravity correction. The isokinetic peak torque during concentric (CON) and eccentric (ECC) knee joint flexors and extensors on the dominant leg before and after the intervention was measured at angular velocities of $60^\circ/\text{sec}$ and $180^\circ/\text{sec}$ (CON) and $60^\circ/\text{sec}$ (ECC). Peak torque H/Q strength ratio was also calculated (CON). The warm-up and setup procedure for the subjects were the same before and after the intervention. Before the tests, the subjects warmed up on a cycle ergometer for 10 minutes by cycling against a load of 60 W at 90 rpm. This warm-up was followed by active dynamic stretching of the psoas, quadriceps, hamstrings, and gastrocnemius muscles.

Plyometric Training Program:

The plyometric training program was held before the subject's regular training sessions. Plyometric training sessions began with a 15-minute warm-up and lasted for some 30 minutes. Subjects were instructed to perform all exercises with maximal effort. During the plyometric training program, the subjects performed a variety of plyometric exercises (double-leg jump, split squat jump, standing triple jump, single leg hop, box jump and hurdle jump, etc). A detailed description of the plyometric training program is given in Table 1. All subjects performed the same number of exercises for the same number of sets and repetitions throughout the study period.

Table 1. Detailed description of the 12-week plyometric training program

Exercise	week					
	1st	2nd	3rd	4th	5th	6th
Tuck jump	2 × 8	2 × 10	2 × 8	2 × 10		
Jump to box	2 × 8	2 × 10	2 × 8	2 × 10	2 × 10	2 × 10
Double leg ankle hop	2 × 8	2 × 10	2 × 8	2 × 10	2 × 10	2 × 10
Double leg vertical jump	2 × 8	2 × 10	2 × 8	2 × 10	2 × 10	2 × 10
Standing long jump			2 × 8	2 × 10	2 × 10	2 × 10
Split squat jump					2 × 10	2 × 10
Exercise	week					
	7th	8th	9th	10th	11th	12th
Standing long jump	2 × 8	2 × 10				
Split squat jump	2 × 8	2 × 10				
Lateral hop	2 × 10	2 × 10	2 × 8			
Single leg box push off	2 × 10	2 × 10	2 × 8	2 × 10	2 × 10	2 × 10
Front hurdle jump	2 × 10	2 × 10	2 × 8	2 × 10	2 × 10	2 × 10
Depth jump			2 × 8	2 × 10	2 × 10	2 × 10
Single leg hop			2 × 8	2 × 10	2 × 10	2 × 10
Standing triple jump				5 × 3	5 × 3	5 × 3

Statistical analysis:

All data obtained are shown as mean ± SD. The paired t-test was used to compare before and after values and p-value was set at less than 5%.

Results and Discussions

The results are shown in Table 2. The average in quadriceps and hamstrings muscle strength (CON) of the U18 players who participated in the Japan High School Handball Championships in 2013 were 130.0 ± 29.4 Nm and 74.2 ± 15.2 Nm, as reported by Moriguchi et al. (2014). Compared with this previous study, female junior handball players in this study were stronger.

The peak torque in the subject's hamstrings and quadriceps strength before and after the training program were compared. After 12 weeks a significant increase (p<0.01) in peak torque was found for the hamstrings strength (CON) at every speed. No significant changes were found for

the quadriceps strength (CON) at any speed, therefore improving ($p<0.01$) the H/Q strength ratio. In addition, knee extension muscle strength (ECC) showed a 10% improvement in muscle strength at every speed after completing the training program.

Table 2. Comparison of isokinetic peak torque in quadriceps and hamstrings strength before and after the plyometric training

Peak torque (N/m)	Angular velocities	pretest	post test	
Knee extention muscle strength	60°/sec (CON)	136.3 ± 14.7	137.9 ± 11.3	n.s.
Knee extention muscle strength	180°/sec (CON)	88.3 ± 9.8	89.8 ± 8.7	n.s.
Knee flexion muscle strength	60°/sec (CON)	76.3 ± 10.1	88.4 ± 8.9	□
Knee flexion muscle strength	180°/sec (CON)	49.1 ± 7.5	58.9 ± 4.9	□
Knee extention muscle strength	60°/sec (ECC)	168.6 ± 32.1	186.8 ± 34.4	n.s.
Knee extention muscle strength	180°/sec (ECC)	169.5 ± 28.0	186.2 ± 28.2	n.s.

Values show mean ± SD. □ : $p<0.01$, n.s. : non significant.

In this study, plyometric training for female junior handball players resulted in an improvement in hamstrings strength. Hewett et al. (1996) conducted a study on female athletes using the combined methods of plyometric training and resistance training for 6 weeks, which demonstrated an improvement in hamstrings strength both before and after training sessions. This study, however, shows that plyometric training alone can improve hamstrings strength. It is well known that resistance training reinforces muscles and improves muscle strength imbalances. On the other hand, very few studies have shown an improvement in leg muscle strength through plyometric training. In one such study, research was conducted on female junior volleyball players who completed a 12-week plyometric training program and showed an improvement in hip abductor and adductor torque (Enjinsu et al. 2014). Furthermore, in a separate study conducted on active women who completed a 6-week plyometric training program, there was no significant change in quadriceps muscle strength but an improvement in hamstrings muscle strength (Kavin and Angela. 2011). The findings of these studies show the same results as that of this study.

Female athletes demonstrate a marked imbalance between hamstrings and quadriceps muscle strength before training intervention (Huston & Wojtys. 1996). H/Q strength ratios at or below 50% may indicate a pathologic condition. It has been hypothesized that H/Q strength ratios lower than 60% can predispose an athlete to ACL injury (Dunnum et al. 1988, Hewett et al. 1999). Hewett et al. (1996) reported that H/Q strength ratios improved from 50% to 65% after their training program. Likewise, in this study, H/Q strength ratios greatly improved from 55% before the training program to 65% after the program (Figure 1). The Medical and Scientific Committee of Japan Handball Association (JHA) claims that an H/Q ratios of over 0.65 is needed to help prevent ACL injuries (Kato et al. 1999). Almost the same figure came out from the results of this study. This suggests that the study program may be effective in preventing ACL injury.

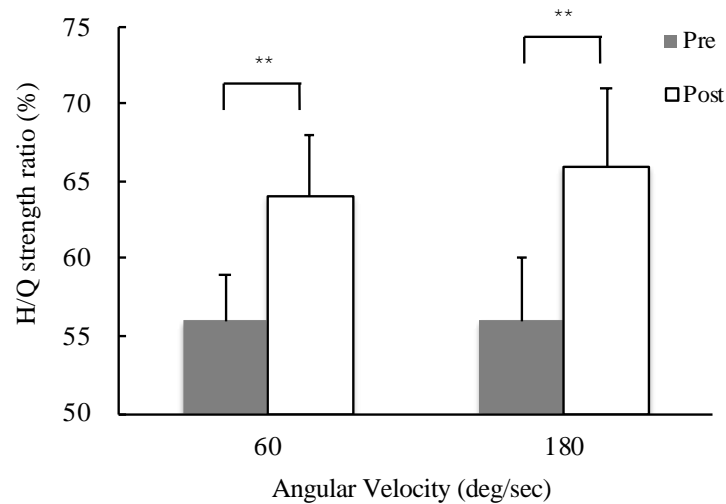


Figure 7. Changes in the H/Q strength ratios before and after the training. **: P<0.01

In addition, the plyometric training program employed in this study enhanced knee extension muscle strength (ECC). Takasugi et al. (1994) suggested that female athletes use knee extension muscle strength (ECC) in order to absorb shocks of jump movements. Kamishima et al. (1996) clarifies that knee extension muscle strength (ECC) and hamstrings strength (CON) are required for landing after jumping and for rapid stopping movements. In the preceding study on female junior volleyball players (Suzuki et al. 2017), plyometric training resulted in an enhancement in knee extension muscle strength (ECC). These results suggest that plyometric training enhances hamstrings muscle strength (CON) as well as improves H/Q strength ratios and increases knee extension muscle strength (ECC).

Conclusion

The results of the present study found that plyometric training is effective in improving hamstrings strength (CON) of female junior handball players. Participants in our plyometric jump training program experienced an increase in hamstrings strength while maintaining quadriceps strength (CON) levels, consequently improving their H/Q strength ratio. These results show that plyometric training can help prevent ACL injury in female junior handball players.

FURTHER TOPICS PRESENTED AT THE SCIENTIFIC CONFERENCE

INTEGRATING INJURY PREVENTION IN HANDBALL ATHLETE DEVELOPMENT

Maarten Barendrecht, Ati Claessen, Linda Coppens. Avans+, Breda, Nederland

Background: The burden of injuries in team handball can be lowered if effective preventive measures are well adopted by handball clubs, trainers and players.

Purpose: To reach consensus between Dutch handball experts on the integration of preventive measures in handball athlete development.

Methods: Based on a literature review of preventive measures and athlete development a focus group of five experts established the theoretical framework for a Delphi-procedure. An expert panel of handball trainers, sports/paediatric physiotherapists, physical education teachers and officials of the Dutch Handball Association were invited to reach consensus on the practical applicability, exercise type, guidance and priority of eight preventive measures for different levels of play and stages of athlete development. Consensus was set at 70% agreement.

Results: Twenty-five experts participated in the Delphi procedure. Preventive measures were linked to handball age categories and levels of play. Consensus was reached on integration of the following preventive measures: basic motor skills, falling skills and stabilisation, coordination and balance from the age of 5 years on; warm up with technical elements from 11years on; mobility and strength training from 13 years on; plyometrics and position specific exercises from 15 years on. Preventive measures were also prioritised (1-8) per age category to enable selection of measures based on available training time and level in practice. Stability, coordination and balance and warm up with technical elements were prioritized in the top 3 for all relevant age categories. Falling skills were seen as 3rd most important in ages 5 to 10 but least important from 15 years on. Mobility and strength were not among the top 3 for all relevant age categories.

Conclusion: Effective preventive measures can be integrated in handball athlete development per age group and level of play to facilitate their implementation. The results from this study can be used as a consensus guideline for clubs, handball schools and/or trainer courses

SOCIAL AESTHETICS AND GRASSROOTS HANDBALL

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From the moment they are born, human beings are social animals. Only by living in real communities and interacting with others can an individual grow to become fully human. Social aesthetics is the science that studies how people live together in their social environment. As a multi-professional discipline it has developed perspectives, concepts, models and behaviors (such as hospitality, dialogic paraverbal and verbal communication, the right time (kairos) and the right place (genius loci), auras and atmospheres, etc.) that enable us to understand and constructively organize the way people live together. Psychosocial development takes place in “development windows” that open up at certain ages and then close again during subsequent stages of the life span. Handball as a team and contact sport appears to be particularly suitable for promoting psychosocial development in accordance with the principles of social-aestheticism. As psychosocial skills are primarily acquired in development windows in childhood and early adolescence, the development and implementation of social-aesthetic perspectives, concepts, models and modes of action in grassroots handball is crucially important. The aim of this lecture is to introduce and discuss the meaning and significance of social aesthetic approaches in general and also in particular in grassroots handball.

TESTING SPECIFIC PHYSICAL PERFORMANCE IN MALE TEAM HANDBALL PLAYERS AND THE RELATIONSHIP TO GENERAL TESTS IN TEAM SPORTS

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Introduction: Team handball is exemplified by frequent changes in intensities and different complex movements during games, whereas physical performance has often been tested predominantly via standardized general tests. The aims of our study were (1) to measure team handball specific physical performance as well as (2) general physical performance tests commonly used in team sports in experienced male team handball players, (3) to determine the relationship between specific and general physical performance as well as between specific aerobic capacity and agility, and (4) to ascertain the relevance of these tests for strength and conditioning professionals.

Methods: Seventy-two male indoor court players performed a game based performance test (GBPT) including team handball specific techniques, upper-body and lower-body strength tests, a 30m sprint test, a counter movement jump (CMJ) test, and an incremental treadmill-running test. To assess the specific physical performance via the general test performance, we employed linear regression calculations. Additionally, a principal component factor analysis was calculated.

Results and Discussion: Linear regression analyses revealed a low correlation ($R < 0.5$) between specific and general aerobic performance, 30m sprinting time and specific agility in the GBPT, jump height in the CMJ test and jump height in the jump shot as well as isokinetic shoulder rotation torque and ball velocity in the jump shot. However, a moderate correlation ($R > 0.5$) was found between specific aerobic performance and specific agility in the GBPT. Principal component factor analysis yielded separate components for specific and general physical performance with a cumulative variance of 69%. The results of the present study clearly indicated that general and team handball specific performance are separate components that should be measured, coached, and implemented separately.

PREVALENCE OF INJURIES IN DUTCH HANDBALL, PRELIMINARY ANALYSIS

Tim Arnts, Linda Coppens, Maarten Barendrecht. Avans+, Breda, Nederland

Background: Dutch handball has gained popularity since the recent successes of the female national team. Downside is the risk of injuries.

Purpose: To gather information on the prevalence and distribution of injuries in Dutch handball for the development and/or implementation of targeted preventive measures.

Methods: In a repeated cross-sectional design, Dutch handball players 16 years or older were asked to fill in a monthly online survey from September 2018 to February 2019. All handball players active in Dutch leagues of any playing level were invited to participate through social media, club mailings and the website of the Dutch Handball Association (NHV). The survey included questions about age, gender, playing level, playing position, the (in)ability to fully participate in handball training and matches, injury type and location and the Oslo Sports Trauma Research Centre Questionnaire (OSTRCQ).

Results: In total, 1148 respondents (female 81%), covering all Dutch playing levels, filled in one or more monthly questionnaires (2290 in total). Monthly prevalence was highest in September (43%), October, November and January (all 40%). Injuries of the knee (29%; female 30%, male 25%), ankle (14%; female 14%, male 17%), shoulder (13%; female 14%, male 10%) and lower leg (12%; female 13%, male 7%) were most frequently reported. Injured players reported mean OSTRCQ scores of 70 for the knee, 62 for the lower leg, 58 for the ankle and 55 for the shoulder. Backs and wing players showed highest prevalences for knee injuries (32%). Ankle injuries were most prevalent (16%) in pivots and goalies, shoulder (18%) and lower leg injuries (18%) in wing players and elbow injuries (10%) in goalies.

Conclusion: Injury prevalence in Dutch handball is high and distributions by body locations are compatible with results from previous handball studies. Preventive measures that have been proven effective in other handball populations can be implemented in Dutch handball as well.

HANDBALL GOALIES' ELBOW, STILL A BIG PROBLEM? PREVALENCE, AETIOLOGY AND CONSEQUENCES IN DUTCH TEAM HANDBALL

M. Barendrecht, H.J.J. Roelofs, L. Coppens. Avans+, Breda, Nederland

Background: Handball goalies' elbow is a common problem in team handball goalies. Up to date information on prevalence and burden is needed to develop treatment and preventive measures.

Purpose: To gather insight in current prevalence, aetiology and associated complaints of handball goalie's elbow in Dutch handball goalies.

Methods: In a cross-sectional survey in March 2018, current- (previous 4 weeks), half season- (August-December 2017) and career prevalence of elbow complaints in Dutch handball goalies (>15 years) were investigated. Prevalence was calculated for each period. The Oslo Sports Trauma Research Centre Questionnaire (OSTRCQ) and the Numeric Pain Rating Score (NPRS) were used to quantify current injury burden and pain during sports respectively. Complaints, aetiology, treatment and preventive options were investigated as well.

Results: Of 809 (75.9% female) respondents, 52.8% suffered from elbow complaints at least once during their career (77.8% more than once). Elbow complaints were (one of) the reason(s) to quit playing in 19% of retired handball goalies (n=361). Of the 448 (78.1% female) goalies still active in the ongoing season, 29.9% reported current complaints with a mean OSTRCQ-score of 30.5 (sd 18.9). Half season prevalence was 27.2%. Injury onset was predominantly acute (70%). High impact shots, overreaching, insufficient strength and incorrect technique were frequently (25.9 - 42.4%) reported contributing factors. Complaints (including pain, reduced range of motion and muscle weakness) lasted less than 1 week in 29.4%, 1- 4 weeks in 27.1% and more than 4 weeks in 43.5% of all cases. Mean NPRS-score was 4.8 (sd 2.2). Bracing/taping and strength training were most common treatment and preventive measures.

Conclusion: Handball goalies' elbow is still a major problem in team handball. Results from this study can be used as a first step to develop adequate treatment and preventive measures.

THE PLAYER'S HEALTH AND SOCIAL ENVIRONMENT - SOME CHARACTERISTICS OF INJURIES IN TOP ELITE FEMALE HANDBALL PLAYERS

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Introduction: Handball is characterized by intense body contact, frequent intermittent running, demanding one-on-one confrontations, and quick direction changes in combination with challenging technique and coordination elements like catching, throwing, passing, and dribbling. Also because of all that demands, in the elite female handball, we are following the phenomena: "the injuries are part of the game". Sports medicine is the most important factor for fast recovery, but also some psychological factors and predispositions are important. At the time of injury, social support can optimize the recovery time. The importance of social support for coping with competitive stressors has been noted previously (Gould et al., 1999; Holt & Hogg, 2002; Rees et al., 2007), and the potential stress-buffering effect has been pointed out (Rees & Hardy, 2004). There are different types of social support, the emotional one is very important.

Objectives: In the assignment, we studied the frequency and characteristics of injuries of top-elite sport female handball players (Champions League level) (N- 51, from 18 to 36 years old; average year: 26.5±0.2) from the point of social support at the time of the injury and recovery period.

Material and Methods: The study was conducted with an online questionnaire, data were processed with the statistical program SPSS. Results: The most common injury in elite women's handball players are sprains (86.3%)(usually of the ankle and the fingers on the hands); and some fractures (52,9%) the knee injuries hold the greatest influence on the course of sporting careers, and knee rehabilitation takes the longest. Only three (5,88%) players are with no injury in the career; players are not looking for external factors of the injury and personal guilt or feeling of responsibility is not detectable; there is not significant correlation between years of active career and frequency of injuries ($X^2 3.181$; $p = 0.528$). During the time of the injury, they assume the support of the family as most important. Next, the support of teammates means the most to them, followed by the support from a physical therapist or masseur. In the time of recovery and especially in returning to an active player status they are missing support from the coach and from other team officials.

Conclusion: The findings revealed the need for optimization of social support in female handball. The importance of good team officials-players relationship (especially at the time of injuries) in order to recover fast as possible, train optimal and perform well after an injury.

EVALUATION OF ANKLE BRACING IN FEMALE YOUTH HANDBALL TALENTS

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Background: Literature prescribes bracing to prevent ankle injuries, but does it really work for female youth handball talents?

Purpose: To evaluate preventive ankle bracing in a real-world setting

Methods: Ankle injuries were registered and evaluated over two consecutive seasons in a group of 21 Dutch female national handball talents (born in '00-'01). During the third season, two different ankle injury prevention policies were introduced and evaluated in this group and a second group of 21 Dutch female national handball talents (born in '02-'03). In the '00-'01 group, all talents who had a previous ankle injury were strongly advised to use bracing during training and matches (in national team and club) in the next season. In the '02-'03 group all talents, regardless of previous ankle injuries, were obliged to use preventive ankle bracing.

Results: Fourteen talents (66%) got injured during the first season, six of them were injured twice. Complete return to play took the talents on average 70 days (range 14-350 days). During the second season fourteen talents (66%) had one or more ankle injuries (21 in total) with an average of 80 days (range 10-292) to complete return to play. Ten talents (48%) already had one or more injuries in the previous season(s). Four talents (19%) were already using ankle bracing in the first season, three talents (14%) started in the second season. During the third season, a total of sixteen talents (79%) in the '00-'01 group were using ankle bracing. A total of eight injuries (38%) occurred in the '00-'01 group in the third season, with an average of 33 days (range 5-60) to complete return to play. In the '02-'03 group, a total of five ankle injuries (24%) occurred in this season. It took the talents an average of 58 days (range 12-93) to complete return to play.

Conclusion: Ankle injuries are a serious problem in Dutch female youth handball players. Bracing policies seem to have positive influence on prevalence and time loss, but further research is needed.

INNOVATION OPTIONS IN THE WORLD OF HANDBALL: FUTURE PROSPECTS AND CHALLENGES

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When environmental changes occur in the world of sports, usually there are major calls for innovation. While innovation can mean many things, it is generally understood as the generation, acceptance, and implementation of new ideas, processes, products or services, new to the relevant unit of adoption.

Handball is one of the most popular team-sports with one of the highest economic values, currently described as affected by the major trend of increased commercialization through big data and digital transformation. Characterized as an evergreen journey, the digital transformation approach is a new way to understand business and technology for all handball clubs. In order to stay economically and athletically competitive, handball clubs are spending an incredible amount of time with lots of digital transformation opportunities as a consequence of the disruption of innovations. Supported by the national governing bodies they are increasingly focusing on digital transformation processes as strategic success factors with specific regard to their products and services and to their stakeholders such as players, fans, sponsors and the likes.

According to academic literature, digital transformation processes have not deeply been investigated in the world of handball yet. Thus this work in progress aims at exploring and detecting innovation options applied to the handball business with special focus on digital transformation (which might include but is not limited to players' analytics, virtual reality, and social media development). Specifically, the paper sets out to examine how clubs (professional/grassroots) assimilate and exploit innovation knowledge and validate potential benefits of its deployment. Devil's Circular - Compartement Syndrome – Rhabdomyolysis

ACTIVITY PROFILE, HEART RATE, TECHNICAL INVOLVEMENT AND PERCEIVED INTENSITY AND FUN IN U11 MALE AND FEMALE TEAM HANDBALL PLAYERS: EFFECT OF GAME FORMAT

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Objective The aim of the study was to compare activity pattern, heart rate (HR), technical involvement and subjective perceptions in U11 boys and girls in five game setups. **Methods** Four girl’s teams and four boy’s teams played a 1-day tournament with 15-min games on five different court setups: medium court size 4v4(M4v4), 5v5(M5v5) and 6v6(M6v6), and large court size 5v5(L5v5) and 6v6(L6v6). Activity pattern, HR, technical involvement, perceived fun and exertion were recorded. **Results** Boys covered more total distance (TD) and high-speed running (HSR, 13-17.99 km•h⁻¹) on the large court compared to the medium court (P<0.05). Boys covered more distance as sprints on the large court compared to medium court with the same number of players (M5 vs. L5; P<0.05). Girls covered more HSR-distance in L5 compared to games at medium size court. Girls had fewer accelerations and decelerations in L6 compared to M4 and higher peak HR in L5 and L6 compared to M5 (P<0.05). Boys and girls had fewer shots on the Large court compared to M4 and scored less goals in L6 compared to M4. **Conclusion** Team handball for U11 boys and girls are a high-intensity physical activity irrespective of court size, even though more distance is covered on the large court. Increasing the court size changed the activity pattern, whereas manipulating the number of players on a fixed court size doesn’t appears to influence activity pattern, HR and technical involvement.

Keywords: Team Handball; Team sport; Children; Small-sided-games

EFFECTS OF SPECIFIC TRAINING ON BIOMECHANICAL RISK FACTORS OF ACL INJURY IN ELITE FEMALE HANDBALL PLAYERS

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Background: Deficient motor control is considered a risk factor for anterior cruciate ligament (ACL) injury in landing and cutting sports [1]. The purpose of this study was to investigate the effects of six-weeks progressive sport-specific sensorimotor training (PSSMT) vs. machine-based hypertrophy training (HYPT) on knee biomechanics and neuromuscular activity of elite female handball players in sport-specific risk situations. In a sub-hypothesis we examined the correlation between knee kinematics and kinesiophobia.

Methods: 19 female athletes participated in this intervention study. 13 female handball players from the third German Handball League were assigned via matched randomization into a PSSMT (n=6) or a HYPT group (n=7). 6 female sports students were tested twice to determine test-retest-reliability. Kinematics and kinetics were captured via a VICON motion analysis system (120 Hz) and two KISTLER force plates (1080 Hz). Surface EMG was collected bilaterally from the gluteus medius (GluM), vastus medialis (VM), Biceps Femoris (BF) and Gastrocnemius Medialis (GM). Functional dynamic testing included a DJ (30 cm) and the modified “Heidelberg-Jumping-Coordination-Test” (mHJCT, adapted from [2]). The mHJCT is a single leg jumping test with an unanticipated change of direction after hitting an overhead goal (jump-land-side-cut=JL-SC, jump-land-stabilize=JL-Stab, jump-land-cross-cut=JL-CC). All subjects underwent a clinical knee examination according to the IKDC 2000 form [3] and filled in questionnaires concerning self-reported knee function and kinesiophobia.

Results: The majority of the tested variables showed good to excellent reliability for the DJ and variable results for the mHJCT. Striking was the throughout excellent reliability for the kinematics of the JL-Stab maneuver for the non-dominant (nd) side (ICC: .844-.948). Regarding group effects PSSMT was superior to HYPT. PSSMT significantly reduced joint excursion in transverse plane for JL-Stab (p=.043) and joint excursion in sagittal plane for JL-SC (p=.011) for the nd side. Latter was involved with an increased BF activity (n.s. group effect). HYPT increased peak valgus for JL-Stab (p=.015) for the nd limb. These findings were accompanied by a decreased GluM and GM activity (n.s. group effect). Kinesiophobia: We found a moderate inverse correlation between higher kinesiophobia and increased peak valgus of the nd side during the DJ (r=-.490, p=.023).

Discussion & Conclusion: PSSMT improved dynamic knee stabilization in transverse plane in unanticipated single leg landings after an overhead ball action; a movement modification which is beyond doubt in favour of ACL injury prevention. HYPT worsened dynamic valgus for the same maneuver. Hypertrophy training without functional input should be considered critically, because it is questionable if the strength transfer is guaranteed in all three planes. Questionnaires

of kinesiophobia should be incorporated in ACL injury prevention research; they might have the potential to identify high-risk athletes without expensive equipment.

[1] Hewett et al. (2010). *N Am J Sports Phys Ther*, 5 (4): 234-251.

[2] Kuni et al. (2008). *Clin J Sport Med*, 18, 415-422.

[3] International Knee Document Committee 2000

PSYCHOMETRIC PROPERTIES AND FACTOR STRUCTURE OF THE COACH'S BEHAVIOUR TOWARDS REFEREES AND FAIR-PLAY SCALE

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Backgrounds: A pedagogical approach to sport leadership must include the coach's behavior toward an effective culture of fair-play (Siedentop, 2004) in taking the development of their own responsibility and others, for the appropriate behaviour. The purpose of this study was to develop a new scale, the Coach's Behaviour towards the Referees and Fair-Play Scale.

Methods: The exploratory factor analysis was administered to a sample of 97 handball coaches, followed by an examination of the relationship between the newly derived factors and the other personal and coaching variables (own experience, gender and age of athletes) measured.

Results: After rotation, four factors expressing coach's behaviour towards referees and fair-play could be identified that accounted for 44% of the variance: determine and rectify athletes' behaviour towards referees and opponents (4 items), advise the passive acceptance of referees' decisions (3 items), promote respect for the referees' role (5 items) and encourage the following rules and fair-play (4 items). One item was dropped from the final analysis due to low item-to-total correlation. Cronbach's alphas were .50 overall and .57 to .41 for the subscales.

Discussion: The obtained results on this new scale structure were acceptable for the initial purpose and the obtained four-factor structure was validated across subgroups by gender, age and the other coaching variables measured. Psychometric properties need to be more rigorously investigated to increase its reliability and the amount of the variance explained in coach's behaviour concerning fair-play and referees' role and decisions.

Keywords: handball, coaches, education, fair-play, psychometrics

TEAM HANDBALL TRAINING IN OVERWEIGHT UNTRAINED WOMEN – NO NEED FOR PRIOR EXPERIENCE TO IMPROVE PHYSIOLOGICAL PARAMETERS

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Short title: Health effects of team handball training

Key-words: Team sports, team handball training, premenopausal women, body composition, maximal oxygen uptake, echocardiographic parameters

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Abstract

Purpose: We tested the hypothesis that participation in small-sided team handball training could provide beneficial effects on cardiovascular, metabolic, and musculoskeletal parameters in overweight premenopausal women with special focus on the importance of prior handball experience.

Methods: A randomized 16 week RCT training intervention in overweight premenopausal women were conducted for three groups; a team handball training group without prior experience (UN; n=13), a team handball group with prior experience (EXP; n=10) and an inactive control group (CON; n=9). Both UN and EXP completed 1.6±0.3 training sessions per week with average heart rates of 84±5 and 85±9% of maximal heart rate, respectively. Cardiovascular, metabolic, and musculoskeletal parameters were assessed before and after the training intervention by DXA scans, blood samples, echocardiography and physical tests.

Results: Compared to CON, UN had significant increases in VO₂max (7±4%) and intermittent endurance performance (26±14%) as well as reduced total fat mass (4±6%), total fat percentage (4±5%) and android fat mass (7±12%), respectively (all p<0.05). Compared to UN and CON, EXP displayed increased left ventricular mass and left ventricular mass index (both p<0.05). Applicable to both UN and EXP was a significant increased proximal femur BMD (1±1%) after the training period compared to CON. There were no significant changes between any of the groups in muscle mass, blood lipids, resting heart rate and blood pressure (all p>0.05).

Conclusion: Small-sided team handball training in overweight premenopausal women was associated with cardiovascular, metabolic, and musculoskeletal adaptations for participants with minimal handball experience, indicating that prior handball experience is not a prerequisite for improving physiological parameters of importance for health.

PLAYERLOAD OF BEACH HANDBALL PLAYERS DURING COMPETITIONS

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INTRODUCTION: Beach handball (BH) games are characterized by high intensity activities (Pueo,2017;Bělka,2015) and few studies have been published on performance analysis of BH (Skandalis 2017;Navarro 2018;Zapardiel 2018a, 2018b;Gkagkanas 2018a,2018b;Cobos 2018a,2018b;Jimenez-Olmedo,2019).To best of our knowledge, only 2 studies investigated the physical demand (Cobos,2011;Pueo,2017) of BH players during matches but no information about the PlayerLoad (PL) of BH is available. Hence, the aim of this study was to identify the external (EL) and internal (IL) PL of youth BH players during official matches. **METHODS:**11 players from the same BH team competed during 7 matches of the YAC17 BH tournament. For the EL, GPS units (Catapult Optimeye S5 and T6, Australia) have been used for PL and PL/minute, whereas for the IL, Polar© H7 heart rate (HR) monitors (Polar©, Kempele, Finland) were used. For a subjective assessment of the IL, Rating of Perceived Exertion (S-RPE) was administered after each game and then the Session-RPE(S-RPE) was calculated. Means and standard deviations were calculated for all the variables. **RESULTS:**EL was lower (PL:100.3±15.8AU;PL/min:3.8±0.7AU/min) than basketball matches (PL:449±118AU;PL/min:4.35±1.09 AU/min)(Fox,2018).The IL(% of time spent in each HR zone, according to Edward's method) was higher(zone 1:24.8±2;zone 2:22.2±5.2;zone 3:18.8±5.8;zone 4:24.3±5.6;zone 5: 14.4±6.1) than the results(zone 1:19.1±16.5;zone 2:25.5±12;zone 3:26±11.5;zone 4:20.3±14.4;zone 5:8.9±14.6)showed by Pueo(2017) about BH players. For the S-RPE results have been 123.8±21.5AU, lower than reported by Fox (2018) (638 ± 194AU). **CONCLUSION:** This was the first study aimed to describe the IL and EL of a BH team; therefore, further research is needed to compare these values with other samples of BH players.

PATHOANATOMY, EVALUATION AND MANAGEMENT OF ATRAUMATIC AND TRAUMATIC POSTERIOR SHOULDER INSTABILITY

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Posterior instability has been considered to represent less than 10% of all instability cases however, posterior subluxation and translational instability can be easily overlooked and misdiagnosed. More recently, there has been increasing recognition of this pathology in active populations.

Competitive athletes are among the most common patients owing to overuse (microtrauma) or a single traumatic episode (offensive linemen, direct blow or a fall on a forward flexed arm) resulting in posterior subluxation or dislocation.

Currently there is limited research into the conservative management of posterior instability, although it is recommended as first-line treatment prior to surgical review, particularly in those with an atraumatic instability mechanism. Patients with atraumatic instability have increased joint volume; the joint capsule is enlarged, the glenohumeral ligament is lax and thin, or the dynamic stabilizers (rotator cuff, deltoid, scapular muscles) may be weak or uncoordinated.

General approach for rehabilitation consists progressive strengthening, proprioception enhancement and active motion with special attention to control scapula and rotator cuff. The program needs to be multidisciplinary with special attention to patient education, in some cases psychological support and time. In posttraumatic cases and failed rehabilitation surgery may be an option. Postoperative rehabilitation is also an important part of the whole recovery process and has to be well planned in advance of surgery.

OPTIMAL PHYSICAL TRAINING: THE BEST WAY TO PREVENT INJURIES IN TEAM HANDBALL?

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Recent studies have shown that team handball match-play imposes substantial physical demands on elite players in the increasing number of matches and national/international tournaments during the competition period, now covering 9–10 months per year. Unfortunately, various studies have also shown that elite team handball, independently from sex, due to these high physical demands bears a high risk for both acute and overuse injuries. Injuries to the lower extremities, especially severe knee joint injuries and muscle-tendon injuries of the thigh and the lower leg are more frequently due to indirect contact or non-contact mechanisms and thus of prime interest in prevention studies and interventions.

In recent years, several studies in team handball have demonstrated promising effects in preventing injuries, especially non-contact and overuse injuries. Typically, these effects have been found in controlled and supervised study settings. Despite scientific evidence from these prevention studies, most prevention training programs, which at present are available in team handball, have not been successfully implemented into the training routine of elite team handball clubs and national teams. We hypothesize that one main reason is because they are mainly delivered in strict, unspecific routines that are not suitable to the normal construction of team handball training.

Moreover, recent meta-analyses indicate, that targeted strength training, when planned and conducted correctly, seems to be superior to multicomponent proprioception and coordination interventions in preventing injuries. The fact that strength training already is highly integrated as daily business in elite sports may be the decisive point in this case. Strength training does not need new facilities, equipment or specialised personnel which makes it cost-effective for athletes and clubs and thus has a higher chance to become accepted and adapted. In addition, strength training may have a higher impact on important modifiable injury risk factors than multicomponent prevention training.

A high level of physical fitness is a precondition for being able to tolerate a high volume and intensity of training and to constantly perform at a high level throughout a whole tournament season without getting overloaded and hence potentially injured. Thus, it is crucial that team handball trainers have an in-depth knowledge of the principles and the effects of the various types of physical training which is essential for the correct individual planning and execution of an optimal physical training program for team handball players. In conclusion, the implementation of well-planned and monitored strength training is of key importance in order to reduce the high number of both acute and overuse injuries in elite team handball. However, in a second step, strength training may be assisted of other targeted prevention interventions like multicomponent proprioception and coordination exercises.

PLANNING OF THE TRAINING IN TEAM HANDBALL

Lars Bojsen Michalsik, University of Southern Denmark, Odense, Denmark

Any training schedule for a team handball player should be based on an analysis of the demands of the game to determine what qualities are important for a good performance. This must be compared with a capacity analysis of the individual players, so that their strengths and weaknesses can be identified. Even though elite team handball is a team sport, the players must be loaded differently. It is important to emphasize that aspects regarding playing positions, individual physical capacity and need for recovery, and gender must be taking into consideration, while designing physical training regimens for team handball players. Knowledge from scientific studies combined with practical experience provides a good basis for the planning of optimal training programs.

It is during breaks between training sessions that the improvement of the physical capacity occurs (supercompensation). Therefore, adequate recovery between training sessions is an important part of proper training planning. The recovery time from training and matches is complex and is typically dependent on the nature of the training/game (intermittent exercise, volume, intensity and duration), the player's training level, the total training volume and the conditions for recovery (diet, sleep, relaxation, treatment, massage etc.), and also outside stress factors such as health, lifestyle, nutrition, psychological stress and environment.

The training must be periodized, so the players will reach the best possible performance in the most important matches/tournaments of the competitive match season. The physical training should be organized with preplanned, systematic variations in training specificity, intensity, and volume in different periods or cycles within the overall training program for the season. Training programs for team handball players should use periodisation (e.g. linear, non-linear and block periodisation) to break up the training into e.g. the off-season, pre-season, in-season (and divide it further to provide multiple peak performances during the competitive period), and the post-season, which should focus on different goals in the various periods of training.

The elements that are crucial for the anaerobic performance are built up faster than the factors which are important for the aerobic performance. Thus, anaerobic training should only be intensified as the competition season approaches. Performance gains and improvements in physiological parameters can be achieved up to important matches and tournaments by using tapers with large reductions in training volume, moderate reductions in training frequency, and maintenance or increase of training intensity.

A sensible training planning requires knowledge of the aims for the training period, the starting level, the different types of training, time perspective for training adaptations, rehabilitation, maintenance and detraining, tapers to matches/tournaments, and concrete planning of training duration, intensity and frequency.

THE STRUCTURE OF NEKA – ACADEMY FOR THE DEVELOPMENT OF HANDBALL

Tamás Mocsai
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Hungary's first state-run handball academy was founded in 2013 in Balatonboglár. The athlete and student of the 140 girls and boys are taught the highest level of training, which is proven by the 18 gold medals earned in a short time in different age groups. The head coaches of the youth national teams are the coaches of the National Handball almost without exception, while 49 players represent NEKA in the teams.

The National Handball Academy wishes to play a leading role in the youth education in Hungary, and aims to use thoughtful, synergy-based training structures. The three pillars of the Academy's work: professional work based on international sports science, the highest level of competition and personality development.

Thanks to the infrastructural developments in recent years, the Balatonboglár sports center has become one of the most beautiful handball centers in Europe.

Nowadays, in addition to the planned sport professional work, the prevention, regeneration and rehabilitation also play an important role in the promotion of sports performance. In the area of the renowned Balaton Coast dormitory, situated in the wonderful ancient park, it is also possible to spend a lot of leisure time there.

Keywords: handball academy, youth development, innovation, whole person education, scientific work

SHARE & PLAY SPORT PROGRAM

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Share & Play is an innovative program for youth and adolescents to learn the values of team sport while they are practicing handball. They simultaneously gain cognitive skills applying different topics such as Geography and Math within the exercises (Beck et al., 2016). Trained professionals teach and coach the new generations, giving them assistance across year and a framework to interact and grow around three pillars: health, education, and social inclusion. The program is designed for young generations to have fun and share experiences within their community, learning and playing as a team all year long, facing the problems of overweight and obesity (Brown et al., 2019). As in professional handball teams, they work to create great values and interaction skills at an early age. During an important developmental time in their lives, Share & Play helps kids to become better able to grow multiple skills like physical, cognitive, and emotional through sport (Hoare et al., 2019). Following the program, kids will be better prepared to face future group activities and to give their best effort (Canal-Dominguez et al., 2017). Share & Play is also a job opportunity for former professional Handball players to solve the problem of unemployment after their retirement. In the program they can get the right tools through a certification and leverage all the values they previously obtained in their sport careers. It is an economic and educational opportunity to go over the challenge of sport retirement. It also brings former professional players a new growth perspective. They become experience Share & Play coaches and apply useful tools ready to make a difference to young generation's life. The program is supported by the EHF and has helped more than 100 children in Germany during their school calendar. The results have been really successful so far, improving the physical skills (54%), their educational skills (43%), and their social behavior (20%) of the participants.

YOUNG HANDBALL PLAYERS – THE PERCEPTION OF THEIR PARENTS IN SPORT CONTEXT

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In recent years, the deviant and negative behaviors of parents during follow-up in their children's sports practice have reached alarming proportions in various sports. This increase may be associated with greater participation of parents, both in the presence in games and in training. With this study, we intend to assess the perception of the athletes about the behaviour of the parents in the sports context, namely in relation to fair play. The sample consisted of young handball players from the Madeira Handball Association, aged 9-16 years of both genders (n = 284, male n = 122, female n = 162) registered by ten clubs and with a minimum of one year of organized sports practice. For the data collection, a questionnaire previously constructed and duly validated was used. The results confirm that the athletes consider positive the presence of their parents, however, the results point to a perception of inadequate behaviors of the parents regarding the referees, mainly by the boys. It was found that the younger the athletes are the greater is the perception of the enthusiastic support of the parents, the greater the volume of instructions to the field, and the perception of a greater emotional discontent of the parents in relation to the problems and incidents of the game and training.

Keywords: Handball, Parents, Perception, Fair Play, Behaviours.

A PATHBREAKING METHOD IN HANDBALL

The Sport Science group's structure
How an organized team work can correlate with the effectiveness of the club or of the national team

Made by: András László Szabó (Performance Manager)
NEKA (National Handball Academy), Balatonboglár, Hungary

Introduction

At NEKA the infrastructure, the staff and the the players, including the leaders are truly one of a kind. Due to everything being at hand NEKA could take a big step forward in the physical and mental aspects of the game.

My job will be to present the structure and the workflow of the team.

Phases, competencies and departments...

Materials and methods

Team structure and projects

The job as a coordinator is making the right decisions for a more effective way of improving performance.

Performance diagnostics-Guiding and aiding 4 seasonal tests, giving feedback to coaches afterwards for every team.

Having weekly tests (twice a week) to determine overall readiness of the players, wellness questionnaire, HRV(Omegawave, Polar). CMJ, Hamstring- for lower body prevention, as how prepared the players are for the trainings. Establishing a huge database for every player.

Performance monitoring-Monitoring the performance of the players daily using Catapult and Polar. Giving feedback to the coaches based on quality objective data for every team. It is an important aspect about the players and how well they can handle the given load, so the the performance increases and the injury risk decreases. So that the mechanical load is bearable for every player.

This way the players can improve a lot, especially in being explosive and in speed endurance.

Strength and conditioning-Organizing the work in weekly microcycles. Where depending on the schedule there's excentric, isometric, concentric work with deloads. These concepts help improving max strength, power and springiness the best.

The results

Better overall readiness, performance output and decreased risk of injury. Stable, winning attitude and improved weight room culture.

Last year out of 4 championships NEKA got 2 gold and 2 silver

National teams:

M U17 Open European Championship 5th place

W U17 European Championship 1st place

The strength and conditioning field has gotten so big, that there are already different branches inside, where specialists can work better in their own territory.

Key words

Teamwork, Competencies, Preventive performance enhancement, long term athletic player development

PHYSIOLOGICAL PERFORMANCE TEST SYSTEM OF NATIONAL HANDBALL ACADEMY

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Approximately there are 140 athletes in our academic system, they are grouped by age and sex. In every season they have to participate in different medical examinations, anthropometric measurements, and a physiological performance tests.

Our physiological performance test system consists 8 different tests; ankle mobility, jump test, eccentric hamstring strength test, core test, push up test, sprint and agility test and an intermittent fitness test. It measure several physical qualities, which influence the athlete's performance like, ankle dorsiflexion mobility, core muscle strength, hamstring strength and imbalances, jump height, maximal running speed, maximal aerobic power, anaerobic speed reserve and change of direction abilities. The main aim of the system is to reduce the risk of injury, besides it increases the performance.

PERFORMANCE MONITORING IN HANDBALL: A NEW DIRECTION FOR THE SPORT

Martin Szücs
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Monitoring in team sports is an important piece of the performance enhancing model. Lot's of quality data is coming out, which can help practitioners improve their teams overall health, improve performance or aid injury prevention. The presentation will provide information on what do we monitor in handball games, what data do we provide to coaches and other staff about the players or the game. Also how can live monitoring help the flow of the trainings and provide quality data to the coaches, which can also help the trainers in making decisions based on objective data. The presentation will be held with case studies.

EFFECTS OF A 6-WEEK TRANSITION TRAINING ON BEACH HANDBALL PLAYERS' PERFORMANCE ON RIGID AND SAND SURFACE

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INTRODUCTON: Beach handball is played during the summer break of indoor team handball schedules as yet. Information about surface-specific transition phase(s) between indoor and outdoor conditions are limited. Thus, the aim of this study was to examine the effect of a 6-week surface-specific transition training (TT) on physical performance on rigid and sand surface.

METHODS: Twenty-nine beach and indoor team handball players (control: 14; TT: 15) were tested pre and post TT on rigid (r) and sand (s) surface in jump (CMJ, DJ, DJ-RSI), sprint (5-10-20 m), COD, and drop distance jump (DDJ) performance. Individual performance thresholds ($> 2*CV$) were set to identify meaningful changes. 2x2x2 repeated measures ANOVAs were used to evaluate differences between factors (time, surface, group; $\alpha = 0.05$).

RESULTS: Significant interaction effects were observed with improvements of 6.0%, 4.2%, 16.3%, 4.8% in CMJ (r), COD (s), DJ-RSI (s) and DDJ (ES 0.75-1.30) for the TT group. For CON, significant decreases of 2.2%, 2.1%, 2.2%, 13.7% in 20 m (r), 10 m (s), 20 m (s), DJ-RSI (s) (ES 0.73-0.83) were detected. Individual responses were $\square 3$ times higher in TT group (26 vs. 72).

CONCLUSION: A 6-week transition training (TT) enables enhancement of vertical and horizontal jump performance in the TT group without limiting players' indoor performance. Sprint performance was maintained on individuals' threshold approach ($2*CV$) compared to CON. Therefore, a TT is practically relevant in team handball players' preparation for the outdoor beach handball season in the summer break.

ON-COURT GAME-BASED TESTING IN ELITE MALE AND FEMALE TEAM HANDBALL PLAYERS

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Introduction: Biological differences between men and women are well known; however, in team handball exists a lack of knowledge for the link between the physical demands in competition and the physical performance during testing in male and female players. Consequently, the aims of our study were to analyse team handball on-court physical performance in male and female team handball players in different performance levels by use of team handball specific testing.

Methods: Thirty-six elite, sub-elite and non-elite male as well as thirty-two elite, top-elite and world-class female indoor court players performed a game based performance test (GBPT). The oxygen uptake, heart rate, blood lactate concentration, ball velocity and jump height in the jump shots as well as running time (in offence, defence, fast break and retreat) were measured.

Results and Discussion: Significant differences in peak oxygen uptake, heart rate, ball velocity, defence, offence and fast break time were found between male elite, sub-elite and non-elite as well as between female world-class, top-elite and elite players. Between elite male and female team handball players significant differences were found in offence and defence time, jump height and ball velocity in the jump shot but not in the peak oxygen uptake and heart rate. In the pauses between the high-intensity movements in the game-based performance test, a female world-class player was able to increase oxygen uptake more compared to an elite player. The results of the present study clearly indicated the importance of specific agility both in offence and defence, in throwing velocity in the jump shot as well as in aerobic performance in elite male and female team handball. The present observations suggest using on-court anaerobic and high-intensity aerobic training in elite male and female team handball additional to commonly used physical training such as strength and power training.

INJURY PREVENTION POLICIES IN DUTCH HANDBALL CLUBS

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Background: Injury incidence in team handball is high but many of these injuries can be prevented by implementing preventive measures. In Dutch handball clubs, many youth teams are trained and coached by volunteers. Higher qualified trainers at senior level come and go. Therefore, club policies are necessary to implement preventive practices on club level.

Purpose: To investigate current preventive policies in Dutch handball clubs.

Methods: An online survey was sent to all (371) Dutch handball clubs in February 2018. Technical committee members/head coaches were asked about club policies regarding injury prevention as well as barriers and facilitators for implementation on club level.

Results: Sixty-seven clubs (18%), covering all competition levels, answered the questionnaire. The mean number of trainers per club was 18 of which on average 30% had a trainer's licence of any level. Of all clubs, 20% had a club policy on injury prevention, in 51% the choice was up to trainers themselves and the other 29% had no clear knowledge of a policy on injury prevention. Only 14% of all clubs had a long-term policy on maintenance of preventive measures. Important barriers for implementation were insufficient knowledge on injury prevention in trainers and/or within the club, as well as lack of implementation competencies within the club. Other barriers were financial, organisational and the high number of volunteers within the club. Important facilitators for implementation were insight in the contents and effectiveness of preventive measures by means of an app and/or yearly in-company workshops. Furthermore, external support from the Dutch Handball Association and support for the implementation process in the club as well as incorporating prevention within athlete development were mentioned.

Conclusion: Injury prevention policies seem to be scarcely implemented in Dutch handball clubs. Externally supported knowledge transfer and implementation management on club level are needed to facilitate the implementation of injury prevention policies in Dutch handball clubs.

THE AMID PROJECT – ATHLETIC MIGRATION AND DUAL CAREER: A CASE FROM HANDBALL

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Introduction: Long-term planning of athletes' career is one of the characteristics of modern sport, including education, migrations etc. The EHF is a partner in Handball 4 Dual Careers, supporting players on their academic and professional paths. Among other dual career projects in elite sport in Europe is also the AMID project. **Methods:** Descriptive and qualitative research methods are combined. The paper presents the structure, methods and aims of the AMID project, as well as a case study (based on a semi-structured interview) of a top elite female handball player. **Results and Discussion:** The AMID project aims to raise awareness and knowledge of the phenomenon of dual career and athletic migration, and to build a network and develop applicable support structures for migrating athletes within the EU including evaluation and implementation of best practices. The overall objective is to support good governance in sport and dual career by tackling the challenges of new economic and social conditions in the EU. Finally, the project will provide practical tools to stakeholders and feed good practices into governance. By expanding the network, exchanging the identified best practices across European policies, and involving national authorities in the process, the AMID project will contribute to the standardisation of European education and sport measures beyond its time frame and also outside of the participating organisations. We checked the aims of AMID through a case study of an outstanding Slovenian female handball player, who has migrated seven times, with different educational experiences parallel to her sports career. **Conclusion:** The AMID project provides one of the models for a dual career of migrating athletes. Migration across borders in the EU is a requirement in many elite sports, also in handball, and a crucial challenge for dual career athletes. The case study of an elite female handball player, who combined her sports career with academic education, can help identify the needs and obstacles in the life of migrating athletes. Due to specific conditions and demands of elite sport, a systematic and well-organized system of support for migrating athletes is needed, especially in the field of education.

PLAYING LEVEL AND POSITION DIFFERENCES IN BODY CHARACTERISTICS AND PHYSICAL FITNESS PERFORMANCE AMONG MALE TEAM HANDBALL PLAYERS.

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ABSTRACT

The primary aim of this study was to examine the anthropometric characteristics, as well as the physical performance of professional handball players classified by playing position and competition level. 20 male players (age: 20.4 ± 0.88 years) from the first handball league and 18 male players (age: 21.3 ± 1.61 years) from the second handball league were categorized as backs (8/8), pivots (5/4), and wings (7/6). The following variables were measured in both groups: peak power; vertical squat jump (SJ); countermovement jump (CMJ); sprint times over 15 and 30 m; handball throwing velocity during the jump shot (JS) and 3 step shot (T3 step); upper and lower limb muscle volumes; Yo-Yo Intermittent Recovery Test. Anthropometric data revealed significantly less muscle volume ($p=0.003$, $\eta^2=0.248$) for second league players (3.13 ± 0.29 l) than for first league (3.71 ± 0.82 l). The cross-sectional area for the first league players was also larger ($p=0.010$, $\eta^2=0.192$). Regarding performance parameters, we found significant league differences in 5/15 (33%) performance parameters ($p<0.05$ and $\eta^2>0.20$): running throw ($\eta^2=0.285$), SJ power ($\eta^2=0.670$), SJ velocity ($\eta^2=0.900$), peak upper limb power ($\eta^2=0.231$) and Yo-Yo-IR 1 ($\eta^2=0.348$). The second league players showed higher SJ velocity than the first league players ($\eta^2=0.900$). In contrast, we detected a greater difference in SJ power ($\eta^2=0.670$), but in favor of the first league players. Pivots had the highest throwing velocity and wings were the fastest (15 m, 30 m sprint), strongest (countermovement jump) and most enduring (Yo-Yo-IR 1) athletes. Backs consistently showed the lowest level throwing velocity and sprint performance. The anthropometric differences between playing levels and playing positions may indicate the advantageous characteristics that the respective positions demand, whereas the playing position differences in physical fitness characteristics may indicate training specificity issues that must be addressed strategically.

GAZE BEHAVIOUR AND SHOOTING STRATEGIES IN HANDBALL PENALTY THROWS

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Aim: The choice of an appropriate gaze strategy in sport can lead to more efficient information processing and thus improved motor performance. The aim of this study was to analyze the relationship between sporting expertise and gaze behavior strategies in penalty throws taken by handball players. **Methods:** 19 expert handball players from the top professional league in Poland and 19 novice players from a junior high school took a total of 190 penalty throws. Eye movements were recorded binocularly using a mobile eye tracking system. The number of fixations, fixation duration, number of fixation in maintaining visual stability in relation to fixation location (goalkeeper, goal sectors) were analyzed. **Results:** There were significant differences between experts and novice players in fixation duration in relation to the location of the goalkeeper ($p=0.010$) and location of goal sectors ($p=0.039$), and in the number of fixations in maintaining visual stability during the proper phase of penalty throw ($p=0.004$). Moreover, during the preparatory phase of the throw, expert handball players had a greater number of fixations located in the areas of the goalkeeper's head ($p=0.001$) and right arm ($p=0.033$). A correlation analysis showed a positive link between throw efficiency and total time of fixation in the proper phase of the throw ($R=0.28$, $p=0.005$). **Conclusions:** The strategy of visual behaviors during the performance of penalty throws in handball differed between experts and novice players in terms of visual localization and the duration and number of fixations. The experts' gaze behavior was more associated with the fixation on the goalkeeper, whereas in novices with the fixation on goal sectors. Finally, the observed longer duration of fixation before the initiation of movement in experts indicates that this strategy may have a positive effect on penalty throw accuracy.

MULTIPLE INVESTIGATIONS OF COPING STRATEGIES AND NEUROMUSCULAR SYSTEM FUNCTIONAL STATE IN THE FEMALE HANDBALL JUNIOR NATIONAL TEAM ATHLETES

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Ensuring of high performance in various sports, individualization of the training process is impossible without taking into account the individual and personal characteristics of athletes. The influence of the properties of the basic nervous processes is manifested in all the mental and physiological components of human behaviour, such as the adaptation and stability of emotional states, the pattern of the sensorimotor response to mental load while processing information of various degrees of complexity, electrical activity of the brain and cardiovascular system, muscular coordination and, in general, in the success of sports activities. The study involved 16 female handball athletes aged 17-19. To determine individual differences in the properties of the main nervous processes (strength, mobility, balance) and individual differences in sensorimotor response a system of psychophysiological diagnostics "Diagnost-1" (MV Makarenko, VS Lizogub) was used. The study of attention, fatigue level, the degree of female athletes training was carried out with the use of mobile electroencephalographic device "Smarting". To identify strategies for coping with stress, the questionnaire "Identifying individual coping strategies" (E. Heim) was used. The E. Heim's technique for revealing individual coping strategies allowed determining the preferred adaptive and non-adaptive styles of coping with stressful situations. Stabilometric study was performed using "Wii balance board". The methods of vectorcardiogram and heart rate variability were also applied. Recommendations based on the testing results were used to individualize the female athletes training during the team formation process for participation in the Euro 2019 Championship.

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