SCIENTIFIC CONFERENCE 2021

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"Digitalization and Technology in Handball – Natural Sciences/The Game/Humanities"

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FOREWORD

Michael Wiederer
EHF President

Although this year's edition of the EHF Scientific Conference was the sixth of its kind, it represented a premiere in the history of the Scientific Conference. For the first time and due to the current circumstances, the EHF decided to host the event in a digital environment. With this step the EHF ensured that in cooperation with the Union of University Teachers (UUHT) numerous professional, medical, technical and scientific experts can come together in times of uncertainty to share their research, findings and ideas on the game of handball, natural science and humanities to ensure the further development of the sport.

The EHF Scientific Conference has always been and will be a forum of communication for handball experts from different backgrounds but with a shared love for the sport. This conference enables everyone in handball to take a broader view at the sports and shape its future according to our common beliefs of making it the most attractive team sport.

The previous editions of the Conference always showed the connection between the handball and the scientific world, with an emphasis on sport related fields. Besides the fields of medical aspects, physical and social health as well as the topic "handball for life", which were covered in previous editions in detail, this year's conference laid its focus on the topic "Digitalisation and Technology in Handball". The realization as well as the title of the conference outline the EHF's approach to develop a digital environment for handball throughout the next years and as always, the EHF Scientific Conference is the perfect opportunity to kickstart sustainable development initiatives within the EHF.

Despite the circumstances this year's EHF Scientific Conference hosted a total of 46 presentations and numerous discussions between the participants and the speakers. This open exchange during every edition of the conference has lighted the excitement for this beautiful sport consistently and shows, that handball is on a path to advance and grow further. It is now time to embrace the future of European handball based on numerous academic approaches that will accelerate our sport's development in a unique way.

I very sincerely thank the members of the 2021 EHF Scientific Conference Organising Committee and the members of the EHF Scientific Network for their efforts in administering and arranging this new experience of an online event, that helped to carry on the legacy of the EHF Scientific Conference which was always made possible with the engagement of the EHF Competence Academy & Network. I hope that the speakers and participants of the 6th EHF Scientific Conference recognize the efforts of the EHF to pay attention to a rapidly developing sports world. The handball world needs you, the scientific experts, to become a part of this development and ensure that handball takes the next step into the digital world to further grow its community.

Michael Wiederer
EHF President

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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 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.

ORAL PRESENTATIONS

THE IMPACT OF COVID-19 PANDEMIC ON HANDBALL REFEREES' PSYCHOLOGY

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George S. Bebetsos, European Handball Federation (EHF), Vienna, Austria

Summary: A novel coronavirus disease (COVID-19) outbreak was first reported in China and is now spreading across nations and continents, resulting in a global challenge against the pandemic COVID-19 outbreak all over the world (World Health Organization, 2020). Sports officials are suffering from many uncertainties and hope to achieve the best possible position under the current circumstances of this global COVID-19 pandemic.

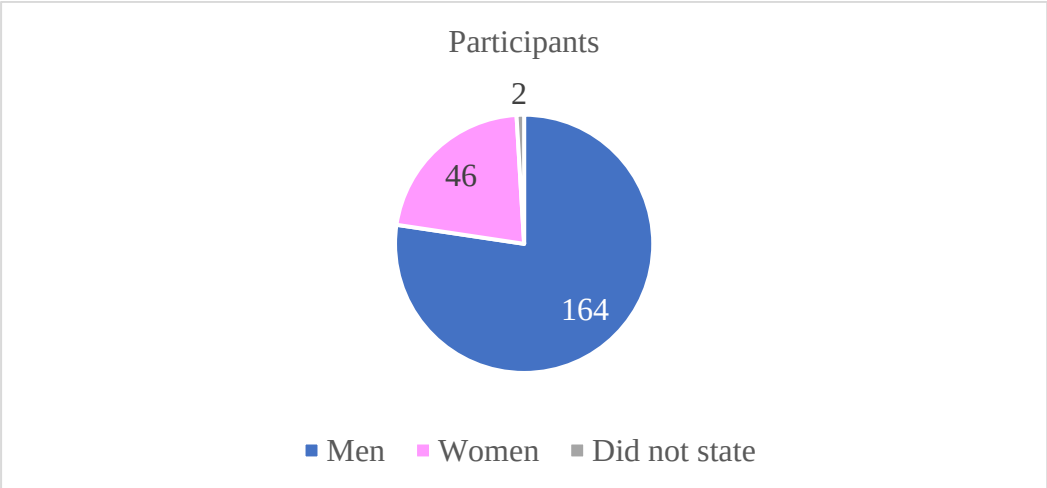
Keywords: ERQ, reappraisal, suppression, handball, officials.

Introduction

The COVID-19 pandemic has affected people's normal physical activity. This happens for both practical and emotional reasons: Pause of competition, closure of gyms and sports venues, restrictions on the movement, etc., that all have dramatically disrupted our daily routines (Corsini et al., 2020; Gallego et al., 2020; Schinke et al., 2020, Cheval et al., 2020). European Handball Federation (EHF) Officiating wanted to research both EHF indoor and beach handball referees, as the mental state in which they find themselves and their psychology as referees is one of its major concerns. The study was ordered by the EHF Officiating division and planned and carried out by the School of Physical Education and Sport Science, of the Democritus University of Thrace, Komotini, Greece.

Material and Method

The sample consisted of 212 international officials (referees), where 164 were men (77.4%), 46 were women (21.7%), and 2 did not state sex preference (0.9%), aged from 21-49 years.



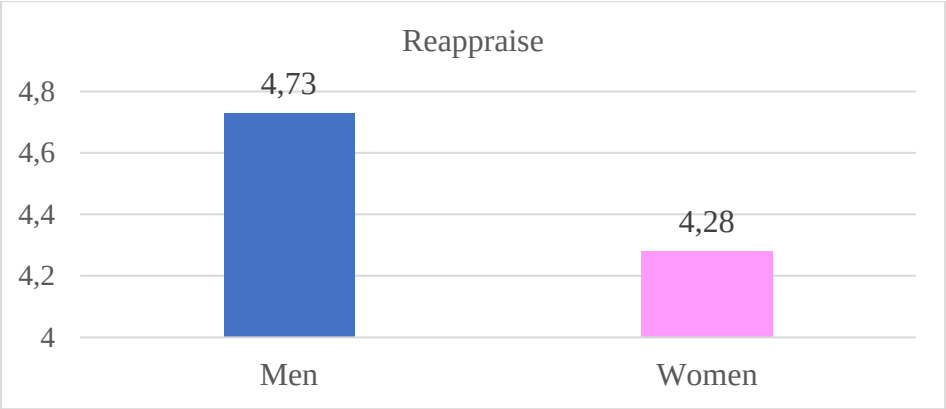
Participants completed the "Emotion Regulation Questionnaire, (ERQ)". The Emotion Regulation Questionnaire (ERQ, Gross & John, 2003) is a 10-item self-report scale designed to assess the habitual use of two commonly used strategies to alter emotion: Cognitive reappraisal and expressive suppression. The items were scored using a 7-point Likert-type scale ranging from 1 (strongly disagree) to 7 (strongly agree). The first dimension ("Reappraisal") consisted of six items, while the second dimension, ("Suppression") consisted of the remaining four items. Scores on the ERQ relate to several coping measures and results generally show that reappraisal is associated with positive adaptations including pleasant emotions whereas suppression is associated with negative adaptations and unpleasant emotions (John & Gross, 2007; Uphil et al., 2012). Evidence suggests that the ERQ has been validated in different languages (e.g., Balzarotti et al., 2010; Uphil et al., 2012; Teixeira et al., 2015; Liu et al., 2017, Bebetsos et al., under publication), and it has been used at sports environment too (Uphill et al., 2012; Wagstaff et al., 2013).

Research data was collected using an electronic form/questionnaire (Google Form), as the researchers considered its use mandatory in compliance with the new Coronavirus protection rules (COVID-19), avoiding unnecessary physical contact and the survey was addressed to officials coming from 50 different European nations (EHF-member National Federations, https://www.eurohandball.com/en/who-we-are/ehf-federations/). The data collection period lasted two months (June-August 2021). The reason for selecting the specific period is related to the reopening of competition activities at the EHF. Participants were informed about all the parameters and ethical issues that governed the research, such as voluntary participation, the anonymity of participants, the right to leave voluntarily at any stage of the questionnaire, and the exclusive use of the data for research purposes. They were informed by providing all the necessary information on the first page of the questionnaire. If they agreed they continued with the procedure.

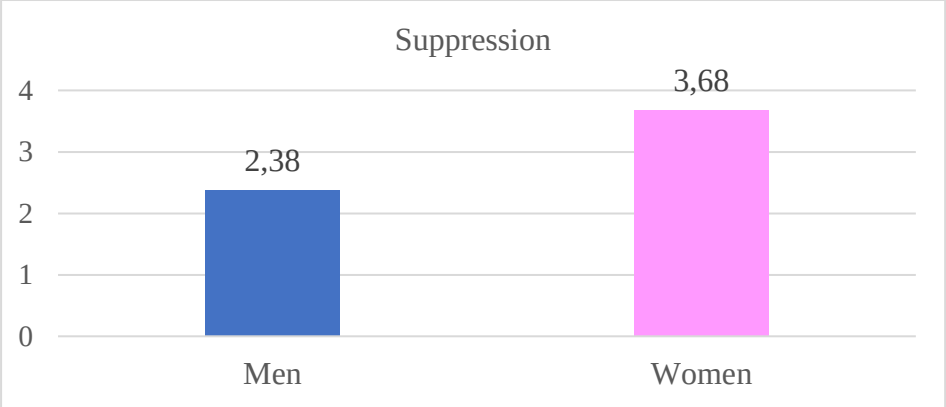
Results

The analyses revealed differences, where men reappraised better than women, and women were more suppressed than men. Additionally, EHF/IHF officials were more suppressed than their EHF colleagues. Reappraisal consists of changing the way one thinks about a situation and it is generally implemented early in the process. Suppression involves inhibiting the expressions of emotions and it is generally implemented later in the process (Santi et al., 2021). One-way ANOVA analyses were conducted to find any differences among sexes (a1,2) and officials' level (b).

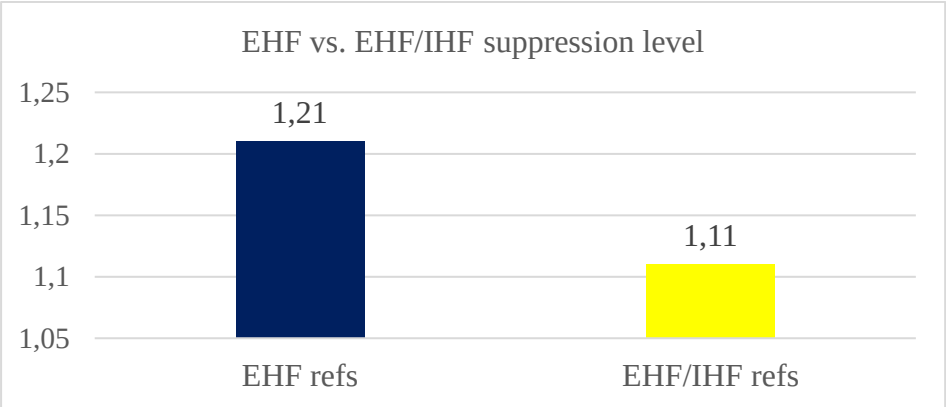
(a1) Reappraise: $F_{2,211}=3.299$, $p< .001$. More specifically, men were more reappraised (M=4.73, SD=1.10), than women (M=4.28, SD=1.31).



(a2) Suppression: F2,211=2.704, p< .001. More specifically, women were more suppressed (*M*=3.68, *SD*=1.28), than men (*M*=2.38, *SD*=1.33).



(b) Officials' level: F2,211=2.136, p< .001. More specifically, the EHF officials were more suppressed (*M*=1.21, *SD*=.302), than the EHF/IHF officials (*M*=1.11, *SD*=.319).



Discussion

The aim of the study was the possible effect of the COVID-19 pandemic on European handball referees' psychology. To our knowledge, no similar studies have been conducted on the specific topic. Therefore, discussion and conclusions from the present study reflect a first attempt to interpret the possible relation of COVID-19 with referees' psychological status. Regarding the first

research question, results proved that COVID-19 differentiated participants according to gender. More specifically analyses revealed that women firstly were more suppressed than men, and secondly, they were less appraised than men. According to the results, women show greater negative psychological responses, and as past research indicated, they are characterized as more sentimental and emotional (Thon et al., 2012; Konstantinidis et al., 2021).

Elite referees (EHF/IHF) appear to be more in control of the situation than their non-elite (EHF) counterparts. While EHF referees appear to have higher levels of suppression than EHF/IHF referees, EHF/IHF referees appear to use "suppression" as a regulatory strategy more frequently than their EHF counterparts. The researchers believe that this result may have been caused by two factors: (a) Either from the difference in experience, in terms of level, type, period, and intensity of the competition to which the two groups had been exposed, or (b) from any kind of mental training the EHF/IHF had received in the past (Ehf-euro.com, 2018, 2020, Eurohandball.com, 2020).

Conclusion

According to the World Health Organization (WHO), the spread of the COVID-19 pandemic raises concerns about increased panic and anxiety in people trapped in a coronavirus threat, either real or theoretical (Bebetsos et. al., 2021). COVID-19 has temporarily changed the way of life for billions of people and will have long-lasting impacts upon both professional and mass sports participation (Konstantinidis et al., 2021). Handball has and will continue to be affected by the pandemic. We can better assist and prepare those who have been affected using such tools. Previous research (Thon et al., 2012; Konstantinidis et al., 2021) supports emotional differences between sexes, with women appearing to be more susceptible. It seems that women are more prone to stress-related disorders such as post-traumatic stress disorder and anxiety disorders (Voitsidis et al., 2020; Konstantinidis, et al., 2021). Thus, their emotional reaction to the Pandemic and its negative consequences led to their negative entrapment. Gender-based differences in emotion regulation and, specifically with regards to “suppression” regulation, confirm the existing literature showing that men tend to suppress their emotions more commonly than women (e.g., Gross & John, 2003). Sport psychology practitioners could support referees in their effort to learn how to regulate their own emotions during stressful situations.

Data Availability Statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics Statement

Ethical review and approval were not required for the study on human participants following the local legislation and institutional requirements.

Author Contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

Acknowledgments

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THE USE OF REFEREE COMMUNICATION SYSTEM IN HANDBALL OFFICIATING

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Summary: Communication among the members of a referee pair is vital to taking the necessary and right decisions. People expect the decision to be fast, clear, and correct. With the use of a wireless communication system, the referees are constantly in contact with each other and able to communicate about all crucial decisions during a match.

Keywords: Officiating, referees, communication, handball, system.

Introduction

Effective audio communication between the officials that referee matches are fundamental, not least when it comes to the analysis of controversial situations. In such situations, the audio signal from the court serves as an additional tool to clarify aspects of the events that have occurred. Over the past years, the EHF cooperated with some of the most known companies in this field, AXIWI (https://www.axiwi.com/) and VOKKERO (https://www.vokkero.com/). The systems used were, mainly, purchased by the EHF and handed over to certain referee pairs, while several of the referee pairs went ahead and purchased a communication system on their own, resulting in the diversity of the systems used at the various EHF competitions and events. For the EHF the need for having all referees not just equipped but also with an aligned communication system is critical. Further, the future of the referee communication functions in officiating (i.e. having the delegate(s) hooked on the communication with the referees, providing audio feed to the TV production, or having direct communication with a potential VAR had to be examined.

Objective

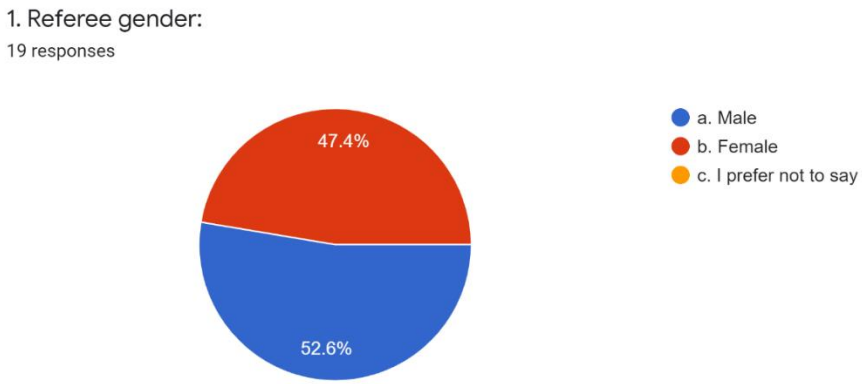
To study the results of implementing advanced referee communication systems during two of the EHF top indoor handball events: The DELO EHF FINAL4 (19/20 May 2021, Papp László Budapest Sportaréna, Hungary) and the EHF FINAL4 Men (12/13 June 2021, LANXESS arena, Cologne, Germany).

Material and Method

The sample consisted of 19 indoor handball referees, where 10 were men (52.6%) and 9 were women (47.4%). Participants completed a self-constructed questionnaire, created to reflect the opinions of the system users, based on their experiences, observation, and feeling of the game control.

Participants were informed about all the parameters and ethical issues that governed the research, such as voluntary participation, the anonymity of participants, the right to leave voluntarily at any stage of the questionnaire, and the exclusive use of the data for research purposes. They were

informed by providing all the necessary information on the first page of the questionnaire. If they agreed they continued with the procedure.



The referee pairs were briefed on the use of the communication system before the events, as well as during the officials' conference that preceded the first day of each event. EHF Officiating staff member and a technician instructed and answered questions for all pairs.

An interface allowing direct audio stream from the referees on the field of play to the OB van in collaboration with the EHFM and the respective TV production crews was also installed. Despite having the audio of the referees on hand, no clips were broadcast on TV before internal evaluation and authorizations.

For assessment purposes, the communication was recorded on the match videotape (separate audio channel) and monitored by EHF Officiating.

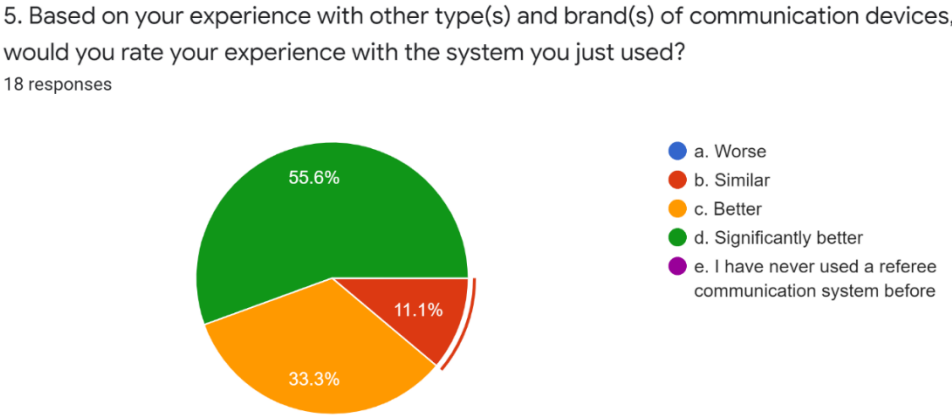
Results

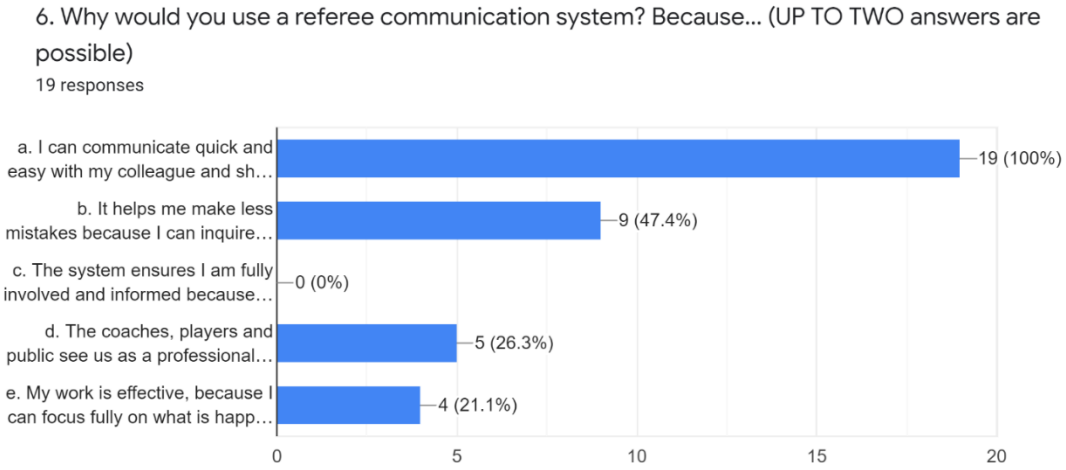
The analyses revealed that clear audio was reported as the main characteristic of the system they used and that the use of a referee communication system gives them more sureness and stability within their common decisions as a referee pair.

Survey results:

- 89,5% of the referees were familiar and experienced with the use of a referee communication system.
- 55,6% of the referees found the communication system they were given significantly better than anything they used before.
- 100% of the referees mentioned that the system allows them to communicate quickly and easily with their colleagues, share important match information and discuss decisions directly, while 47,4% help them make fewer mistakes.
- They all (100%) found the system to provide them with high-quality audio and strong robustness to interferences (57,9%).
- Clear audio was reported (100%) as the main characteristic of the system they used.

- 94,7% feel that the use of a referee communication system gives them more sureness and stability within their common decisions as a referee pair.
- 84,2% and 83,2% reportedly would prefer to have the match delegate(s) in the communication loop during the match.
- For 63,2% of the referees, the use of the communication system can make a difficult decision more acceptable.
- All (100%) referees agree that any communication system can improve their performance.
- The phrases better describe their experience with the system they were given:
    - Clear communication (47,4%)
    - Better game control (26,5%)





a. I can communicate quick and easy with my colleague and share important match information and discuss decisions directly

b. It helps me make fewer mistakes because I can inquire directly about important match information with my colleague

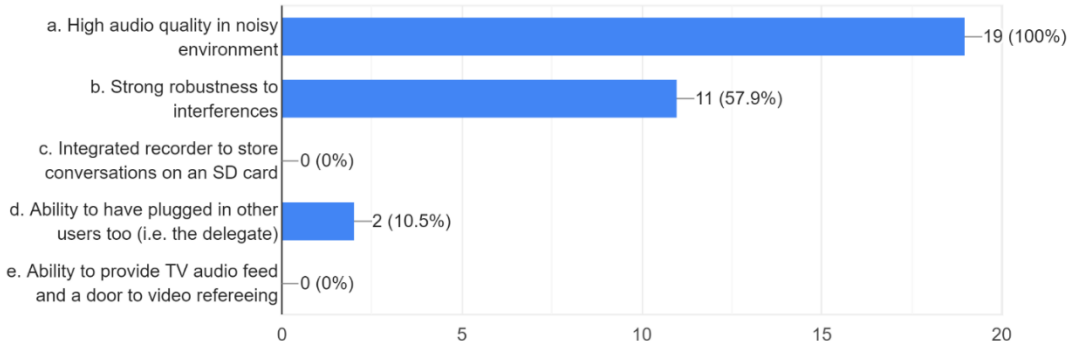
c. The system ensures I am fully involved and informed because I am hearing everything

d. The coaches, players, and public see us as a professional referee team by using a system that helps to take correct(er) decisions

e. My work is effective because I can focus fully on what is happening during the game

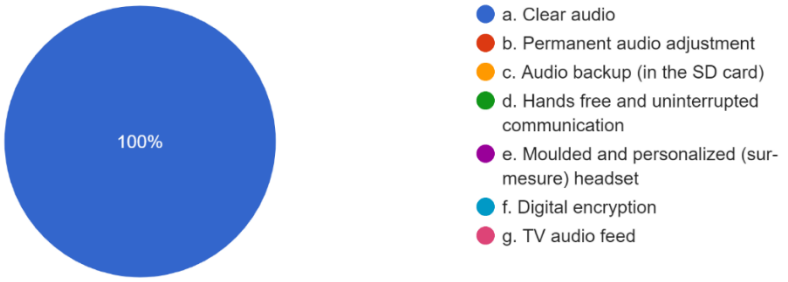
7. If you were going to choose a referee communication system (regardless of its price), which TWO of the following characteristics would play the most important role in your final choice?

19 responses



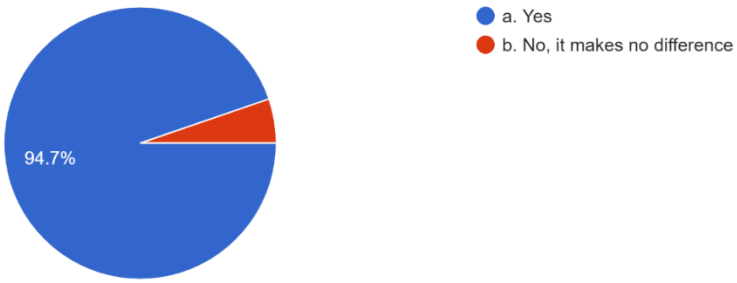
8. Which one of the characteristics of the referee communication system you just used did you enjoy the most?

19 responses



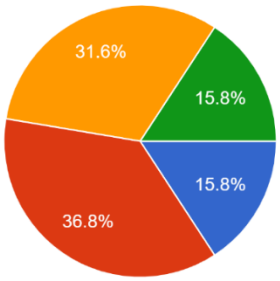
9. Do you feel that the use of a referee communication system gives you more sureness and stability within your common decisions as a referee pair?

19 responses



11. Given there are two delegates at the Table: The match supervisor and the referee observer. With whom would you like to be connected?

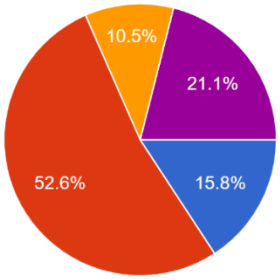
19 responses



- a. With the match supervisor
- b. With the referee observer
- c. With both
- d. With no one; I prefer to communicate only with my colleague

10. Would you see the direct communication during the game between the referees and the Table (delegate, timekeeper, scorekeeper) in the future as necessary?

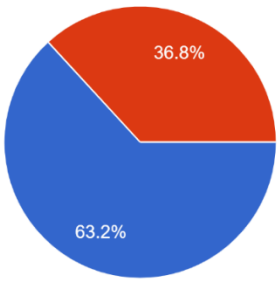
19 responses



- a. No, I don't want any kind of coaching, guidance or info from outside during my game
- b. Yes, with the delegate(s)
- c. Yes, with the delegate(s) and the timekeeper
- d. Yes, with the delegate(s) and the scorekeeper
- e. Yes, with all of them (delegate-s, time and scorekeeper)

12. Can the use of the referee communication system make a specific referee decision (a progressive punishment mostly) more acceptable?

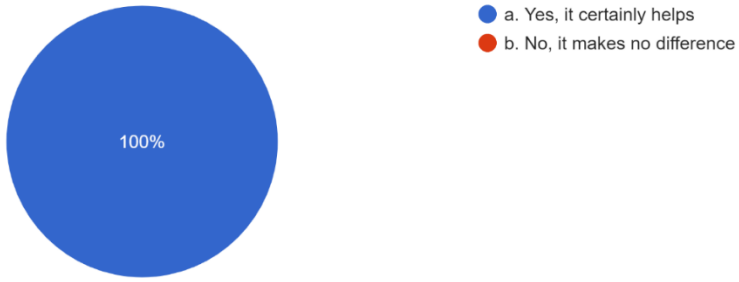
19 responses



- a. Yes
- b. No, it makes no difference. What matters is the way that the referee sells his/her decision

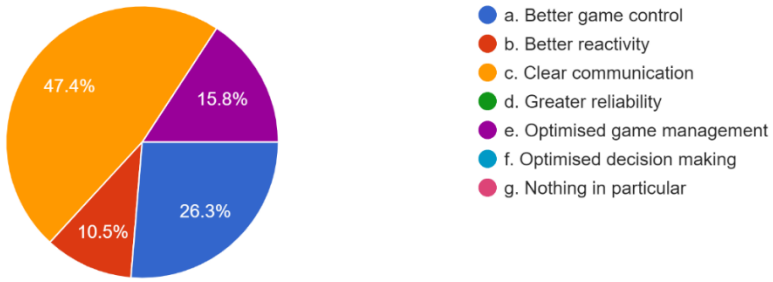
13. Do you feel that using a referee communication system can improve your performance as a referee?

19 responses



14. Which sentence better describes your experience with the referee communication system you just used?

19 responses



Conclusions

Management, control, and ultimately building a better game requires good decision-making by the referees. A good tool of communication will allow the referees to engage the offenders' attention, project confidence in the decision, and promote a perception of fairness. High audio quality in any noisy environment and strong robustness to interferences are critical characteristics demanded both by the EHF and the referees.

Selected referee communication audio clips among them or with the other match stakeholders (i.e. players, coaches, delegates, ball boys, etc.) can create TV content and be a positive step for fans and handball itself, showing the 'other face' of the referees. Anything which adds value to the fan and TV viewer, and demystifies the referees, has got to be something that sports organizations should consider.

Data Availability Statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics Statement

Ethical review and approval were not required for the study on human participants following the local legislation and institutional requirements**.**

Conflict of Interest: The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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GENDER DIFFERENCES IN GAME ANALYSIS PARAMETERS AT THE 2020 TOKYO OLYMPICS AND THE COMPARISON OF WOMEN'S HANDBALL IN OLYMPICS WITH WECH 2020

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Summary

The aim of this study is to determine the gender differences in Tokyo Olympics and to compare women's data with WECh values. About gender differences, there are statistically significant differences between male and female handball players in some parameters. Also comparison of the Olympic and WECh games some statistically significant differences were found. As a result, the tactical approaches and the individual skills of the handball players affect the match scores.

Introduction

Game analysis in team handball is used in all dimensions in top national divisions, tournaments, Continental Championships, World Championships and the Olympics. It is an indispensable fact that game analysis results targeting individual player analysis, opponent analysis, tournament analysis, longitudinal analysis, running profile analysis, tactical analysis or different research problems, contribute to the applications in training. In addition to these, it is very important to analyze the whole season of a team and to approach the next season with the right determinations, both in terms of team setup and in terms of reflecting all the requirements of handball to the training. Results-oriented approach based on cumulative statistic is one of the main topics of tactical analysis in handball, identifying individual or collective parameters that significantly contribute to the success of the team. Many levels of success could be distinguished with a clear hierarchical relationship between them in researches regarding tactical analysis in team handball;

1. Team’s final ranking (Bilge, 2012; Gutiérrez & Ruiz, 2013);
2. Match outcome, expressed by goal difference (Lago et al., 2013; Ohnjec et al., 2008; Srhoj et al, 2001; Vuleta et al., 2007) or win and loss (Foretic´ et al., 2013 ; Rogulj et al., 2004);
3. Goal scoring (Lozano & Camerino, 2012; Rogulj et al, 2004).
4. Physiological aspect (Chelly et al., 2011, Povoas et al., 2012, Souhail et al., 2010, Michalsik, 2013, Hulka et al., 2014, Del Coso et al., 2013a, Del Coso et al., 2013b, Del Coso et al., 2012, Barbero et al., 2017).

Analysis of the technical and tactical aspects of performance enabled the identification of the key indicators of offense and defense that better distinguish teams' winning and losing performance and characterize individual player's performance in elite handball (Foretic et al., 2013).
The aim of this study is to determine the gender differences in Tokyo Olympics and to compare women's data with WECh values

Methods

Match analysis reports taken from the official web pages of 2020 Olympics and WECh were used.In order to determine the gender differences in Tokyo Olympics, five research problems were investigated according to gender.

1. Goal throw efficiency.
2. Offensive parameters.
3. Defensive parameters.
4. Goalkeeper performance parameters.
5. Usage of players in rotation by the coaches.

In order to compare Olympic women's data with WECh values, three research problems were investigated according to tournaments.

1. Goal throw efficiency.
2. Offensive parameters.
3. Goalkeeper performance parameters.

SPSS 17 package program was used for statistical analysis. Parametric test was applied because it showed normal distribution. The t-test was applied for the independent sample to determine the Tournament differences of the parameters obtained from the handball players participating in the Tokyo Olympic Games. In order to find the difference between Tokyo Olympic Games and European Championships in terms of the parameters obtained, the t-test was applied for the independent sample.

Development

The aim of this study is to determine the gender differences in Tokyo Olympics and to compare women's data with WECh values. In this study, statistical differences in the parameters obtained from male and female handball players participating in the Tokyo Olympic Games according to their genders are given in tables and findings.

Goal throws performance parameters were compared with women and men (Table 1).

Table 1. T-test results of the differences of goal throw parameters by gender, in Tokyo Olympic Games

Goal Throw Parameters	Gender	N	Mean	SD	t	df	p
Goal throws (%)	Male	12	61,91	4,29	0,856	22	0,40
	Female	12	60,50	3,80			
6m shots (%)	Male	12	63,25	4,04	0,753	22	0,46
	Female	12	61,41	7,40			
Wing shots (%)	Male	12	65,00	6,29	1,993	22	0,06
	Female	12	56,08	14,16			
9m shots (%)	Male	12	68,83	21,71	0,949	22	0,35
	Female	12	40,33	8,41			
7m shots (%)	Male	12	76,00	9,23	0,176	22	0,86
	Female	12	74,83	21,09			
Fast break shots (%)	Male	12	80,16	4,91	0,251	22	0,80

	Female	12	79,58	6,37			
Breakthrough shots (%)	Male	12	31,50	12,74	-0,068	22	0,95
	Female	12	77,41	10,77			

When table 1 is examined, there is no statistically significant difference between of male and female handball players in the goal throw efficiency parameters ($p>0.05$). In other words, similarity was determined in the percentages of shooting performance during the matches of male and female handball players.

Offensive performance parameters were compared with women and men (Table 2).

Table 2. T-test results of offensive performance parameters by gender, in Tokyo Olympic Games

Offensive Parameters	**Gender**	**N**	**Mean**	**SD**	**t**	**df**	**p**
Assist	Male	12	84,75	28,42	-0,47	22	0,64
	Female	12	90,16	28,04			
Turnover	Male	12	61,75	10,99	-3,05	22	0,001*
	Female	12	78,25	15,17			
Attacks per game	Male	12	53,26	1,76	-4,29	22	0,000*
	Female	12	57,14	2,58			
Attack efficiency %	Male	12	54,14	4,86	2,752	22	0,01*
	Female	12	49,28	3,69			

* ($P<0,05$)

When table 2 is examined, there is a statistically significant difference between the turnovers, attacks per game and attack efficiency of the male and female handball players ($p<0.05$). According to this finding, it was determined that while women were superior in turnovers and attacks per game, men were superior in attack efficiency.

Defensive parameters were compared with women and men (Table 3).

Table 3. T-test results of defensive performance parameters by gender, in Tokyo Olympic Games

Defensive Parameters	**Gender**	**N**	**Mean**	**SD**	**t**	**df**	**p**
Stealing	Male	12	18,91	8,15	-1,421	22	0,17
	Female	12	23,33	7,03			
Block	Male	12	12,08	6,43	0,13	22	0,90
	Female	12	11,75	6,12			

When table 3 is examined, there is no statistically significant difference between the defensive parameters of male and female handball players ($p>0.05$). In other words, it was determined that the stealing and blocking parameters applied by male and female handball players during their matches were similar.

Goalkeeper performance parameters were compared with women and men (Table 4).

Table 4. T-test results of goalkeeper performance parameters by gender, in Tokyo Olympic Games

Goalkeeper Performance Parameters	Gender	N	Mean	SD	t	df	p
Saves %	Male	12	26,91	3,26	-0,102	22	0,92
	Female	12	27,08	4,62			
6m saves (%)	Male	12	29,25	6,13	0,93	22	0,36
	Female	12	27,08	5,24			
Wing saves (%)	Male	12	26,00	6,38	-1,388	22	0,18
	Female	12	31,08	10,96			
9m saves (%)	Male	12	40,66	7,52	-1,077	22	0,29
	Female	12	43,91	7,25			
7m saves (%)	Male	12	16,41	9,50	0,891	22	0,38
	Female	12	13,16	8,33			
Fast break saves (%)	Male	12	16,00	7,63	0,124	22	0,90
	Female	12	15,66	5,38			
Breakthrough saves (%)	Male	12	14,83	9,92	-0,991	22	0,33
	Female	12	18,08	5,51			

When table 4 is examined, there is no statistically significant difference between goalkeeper performances parameters of the male and female goalkeepers ($p>0.05$). In other words, it has been determined that there is a similarity in the parameters of the goalkeeper performances of the male and female handball goalkeepers during their matches.

The usage of players in rotation by the coaches were compared with women and men (Table 5).

Table 5. T-test results of the usage of players in rotation by the coaches by gender, in Tokyo Olympic Games

The usage of players in rotation	Gender	N	Mean	SD	t	df	p
0-15 minutes	Male	12	18,25	7,22	0,488	22	0,63
	Female	12	16,66	8,59			
15-30 minutes	Male	12	29,75	15,99	0,367	22	0,72
	Female	12	27,75	10,02			
30-45 minutes	Male	12	27,50	6,97	-0,09	22	0,93
	Female	12	27,83	10,74			
45-60 minutes	Male	12	17,41	6,94	0,498	22	0,62
	Female	12	15,83	8,55			
Average per player	Male	12	23,22	5,24	0,584	22	0,57
	Female	12	22,02	4,89			

When we look at the usage of players in rotation by the coaches (Table 5), there is no statistically significant difference in this parameters of male and female teams ($p>0.05$). In other words, it was determined that the rotational game parameters applied by male and female handball players during their matches were similar. In order to find the differences between Tokyo Olympic Games and European Championships in terms of the parameters obtained, the t-test was applied for the

independent sample.Goal throws performance parameters were compared with Olympics and WECh (Table 6).

Table 6. T-test results of goal throw parameters by tournament.

Goal Throw Parameters	Tournament	N	Mean	SD	t	df	p
Goal throws (%)	2020 Olympics	12	60,50	3,80	3,23	26	0,00*
	2020 WECh	16	55,56	4,15			
6m shots (%)	2020 Olympics	12	61,42	7,40	-2,28	26	0,03*
	2020 WECh	16	69,75	10,91			
Wing shots (%)	2020 Olympics	12	56,08	14,16	-0,29	26	0,77
	2020 WECh	16	57,25	6,39			
9m shots (%)	2020 Olympics	12	37,42	6,52	-1,04	26	0,31
	2020 WECh	16	39,38	3,32			
7m shots (%)	2020 Olympics	12	74,83	21,09	0,73	26	0,47
	2020 WECh	16	70,44	10,37			
Fast break shots (%)	2020 Olympics	12	79,58	6,37	2,47	26	0,02*
	2020 WECh	16	70,25	11,82			
Breakthrough shots (%)	2020 Olympics	12	77,67	6,69	2,43	26	0,02*
	2020 WECh	16	66,31	15,08			

*(p<0,05)

When table 6 is examined, there is a statistically significant difference between the parameters of total goal throw, 6 m, fast break and breakthrough shots efficiency (p<0.05). According to this finding, it was determined that total goal throw, fast break and breakthrough shots parameters of the female handball players in the Olympic games were higher. On the other hand it is seen that the 6 m shoots efficiency of female handball players in the European championships is higher. Offensive performance parameters were compared with Olympics and WECh (Table 7).

Table 7. T-test results of offensive parameters by tournament.

Offensive Parameters	Tournament	N	Mean	SD	t	df	p
Attacks per game	2020 Olympics	12	57,14	2,58	2,84	26	0,01*
	2020 WECh	16	54,47	2,37			
Attack efficiency %	2020 Olympics	12	49,29	3,70	2,09	26	0,04*
	2020 WECh	16	46,19	4,02			

* (P<0,05)

When table 7 is examined, there is a statistically significant difference between the parameters of attacks per game and attack efficiency ($p<0.05$). According to this finding, it was determined that for these parameters of the female handball players in the Olympic games were higher.
Goalkeeper performance parameters were compared with Olympics and WECh (Table 8).

Table 8. T-test results of goalkeeper performance parameters by tournament

Goalkeeper Performance Parameters	Tournament	N	Mean	SD	t	df	p
Saves %	2020 Olympics	12	27,08	4,62	-1,50	26	0,15
	2020 WECh	16	29,44	3,71			
6m saves (%)	2020 Olympics	12	27,08	5,25	2,88	26	0,01*
	2020 WECh	16	18,94	8,65			
Wing saves (%)	2020 Olympics	12	31,08	10,97	0,04	26	0,97
	2020 WECh	16	30,94	6,60			
9m saves (%)	2020 Olympics	12	43,92	7,25	1,31	26	0,20
	2020 WECh	16	40,63	6,00			
7m saves (%)	2020 Olympics	12	13,17	8,33	-2,08	26	0,05*
	2020 WECh	16	20,25	9,33			
Fast break saves (%)	2020 Olympics	12	15,67	5,38	-1,16	26	0,25
	2020 WECh	16	18,94	8,52			
Breakthrough saves (%)	2020 Olympics	12	18,08	5,52	-1,68	26	0,10
	2020 WECh	16	23,63	10,31			

*($p<0,05$)

When table 8 is examined, there is a statistically significant difference between the parameters of 6m – 7m saves ($p<0.05$). While 6m saves of the female goalkeepers in the Olympic games were higher than the female handball players in the European championships, 7m saves have opposite results.

Conclusion

In this study, gender differences in 2020 Olympics game analysis parameters were examined. Secondly comparison of the game analysis parameters between 2020 Olympics and WECh games were examined.

The main findings for gender differences were that, no major differences in the general goal throw, positional efficiency, assists, stealing, block, goalkeeper performance and the usage of players in rotation parameters according to the gender in 2020 Olympics. Turnover, number of attacks per game and attack efficiency (%) parameters between men and women were statistically different.

For turnovers, we can say that the number of turnovers is higher for women. On the other hand, although women used more attack per game, their offensive efficiency was found to be less.
From the point of view of similar match parameters, we can say that modern handball is getting closer to each other in both men and women. The fact that ball handling, passing and holding techniques are more efficient reduces turnovers in men. The fact that women are less successful although they attack more per game can be interpreted in different approaches. Individual goalkeeper efficiency, fast break tactics, personal goal throw preferences can effect this result.
The main findings of the Michalsik & Aagaard's (2015) study were that substantial gender differences were observed as male players demonstrated more physical, strength related confrontations with the opponents and performed more high-intensity work than female players, whereas female players showed a higher relative workload during match play compared to male players.
Iannaccone et al (2021) found no statistically significant gender differences were found for beach handball game analysis parameters.
Gender difference studies in handball are generally on physiological and biomechanical features, and there are not many studies on match analysis parameters.
The top seven teams in the Women 2020 Olympic standings are from the continent of Europe. For this reason, WECh and Olympic match analysis parameters were compared. According to studies' finding, it was determined that total goal throw, fast break and breakthrough shots parameters of the female handball players in the Olympic games were higher. On the other hand, it is seen that the 6 m shoots efficiency of female handball players in the European Championships is higher. The high value of total goal throw, fast break and breakthrough shots parameters may be due to the matches of European teams with other teams. The use of more 6m throws in WECh may also be due to the center of the defensive toughness and the frequency of the defensive players. The same interpretation can be made for the number of attacks and attack efficiency to be higher in the Olympics. 7m saves difference in favour of WECh can be explained by individual success.
Bilge (2012), from his study comparing international tournaments, emphasized that European teams are the locomotive of modern handball.
As a result, it has been observed that the European teams leading the world handball are more successful than the other teams in the important parameters affecting the attack performance. Goalkeeping activity in favor of other teams can be evaluated as individual success.
It is a fact that European handball is the leader in the world. Too many European teams targeting success also increases the quality of competition. At this stage, it can be said that the European teams have applied all the stages of the fast break attack very well to reach the simple goal.
It takes mastery to analyze a performance. For this reason, the evaluation result will be magnificent if the correctly constructed analysis studies are supported by the statistics obtained with the correct numbers.
Every handball coach wants to be able to put her team's performance into numbers hundred percent. What will bring this assessment closer to hundred percent is the large number of studies on this subject.

WHICH GAME ANALYSE PARAMETERS AFFECTED THE RANKING IN HANDBALL AT THE 2020 TOKYO OLYMPICS?

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Summary

The aim of this study was to determine the objective game analysis parameters that bring success. In this study teams ranked in the Olympics were evaluated in three groups what we call quadrant (1-4, 5-8, 9-12) both in women and men. When the results are examined in male and female players, some parameters show superiority according to the ranking. As a result, the first four teams are more effective in the match analysis parameters that bring success.
Key words: Team handball; game analysis; ranking differences.

Introduction

It is not easy to define team handball performance numerically due to its complex and multifactorial nature. Different technical – tactical – physiological – psychological – sociological – anthropometric - talent level factors and of course their relationships with each other effect the whole performance. It should also be remembered that handball is a team sport that beautifies with individual differences. Besides running, jumping, pushing, change of direction, side stepping etc abilities like the other team sports, handball is strongly influenced by the specific movements to the handball performance (ball handling, passing, faking, dribbling, throwing, checking, blocking etc) parameters, however, tactical concepts, social factors as well as cognitive aspects. Finally, as in other team sports nutrition, illness and injuries as well as external influences of materials and environmental conditions could influence the performance in team-handball (Bilge 2012, Gomez et al., 2014, Gruic et al., 2016).

In recent years; trainers, analyzers and scientific researchers have worked on various parameters in handball game analysis for observing, analyzing and evaluating the performance of handball players and teams (Ohnjec et al., 2008, Srhoj et al., 2001). Besides all these, the most important expectation of the trainers was the correct evaluation of the analysis and the reflection of its effects on the trainings. For this reason, significant statistical findings analyzed by data's collected from match analysis systems should be interpreted according to technical, tactical or physiological aspects of performance (Volossovitch, & Gonçalves 2003, Vuleta et al., 2003). This will represent a strong argument for the organization and evaluation of the training applications (Passos et al., 2017).

Methods

Match analysis reports taken from the official web pages of 2020 Olympics were used. Four research problems were investigated in both men and women.

1. Goal throw efficiency according to the ranking.
2. Offensive parameters
3. Goalkeeper performance parameters
4. Usage of players in rotation by the coaches

SPSS 17 package program was used for statistical analysis. Kruskall Wallis H-test was applied for the difference of the parameters obtained from the male and female handball players participating in the Tokyo Olympic Games according to the ranking.

Development

The aim of this study was to determine the objective game analysis parameters that bring success. In this study teams ranked in the Olympics were evaluated in three groups what we call quadrant (1-4, 5-8, 9-12) both in women and men. In this section, the statistical analysis results obtained for some parameters of male handball players participating in the Tokyo Olympic Games are given with tables and findings. Goal throws performance parameters obtained from male handball players were examined according to the ranking (Table 1).

Table 1. Kruskall Wallis H-test results regarding the difference of goal throw parameters according to the ranking obtained from male handball players participating in the Tokyo Olympic Games.

Goal Throw Parameters	Ranking	N	Mean	SD	Min	Max	X^2	p
Goal throws (%)	First 4 teams	4	66,25	2,75	63	69	8,138	0,01*
	5.-8. teams	4	61,25	3,20	58	64		
	9.-12. teams	4	58,25	2,50	55	61		
6m shots (%)	First 4 teams	4	64,75	4,99	58	69	0,379	0,70
	5.-8. teams	4	62,25	4,57	57	67		
	9.-12. teams	4	62,75	3,09	60	67		
Wing shots (%)	First 4 teams	4	69	8,60	58	79	1,491	0,28
	5.-8. teams	4	64,25	2,50	61	67		
	9.-12. teams	4	61,75	5,37	56	69		
9m shots (%)	First 4 teams	4	43,5	6,24	36	51	0,463	0,64
	5.-8. teams	4	40	4,08	36	44		
	9.-12. teams	4	37,5	13,40	19	51		
7m shots (%)	First 4 teams	4	85	2,94	82	88	5,374	0,03*
	5.-8. teams	4	69,75	10,14	60	79		
	9.-12. teams	4	73,25	5,56	67	80		
Fast break shots (%)	First 4 teams	4	82	6,21	75	89	0,41	0,68
	5.-8. teams	4	79,75	5,18	75	86		
	9.-12. teams	4	78,75	3,94	73	82		

Breakthrough shots (%)	First 4 teams	4	86,25	4,50	81	90	2,767	0,12
	5.-8. teams	4	74,5	7,32	64	81		
	9.-12. teams	4	71,5	13,77	55	88		

* (P<0,05)

When table 1 is examined, the total shot and 7 m shot parameters of the male handball players show statistically significant differences according to the rankings of the teams (p<0.05). Examining the group originating from this differences, it was determined that the teams in the first quadrant were superior to the other teams. There is no significant difference according to the order in other parameters obtained (p>0.05).

Attack performance parameters obtained from male handball players were examined according to the ranking (Table 2).

Table 2. Kruskall Wallis H-test results regarding the difference of attack parameters according to the ranking obtained from male handball players participating in the Tokyo Olympic Games.

Offensive Parameters	**Ranking**	**N**	**Mean**	**SD**	**Min**	**Max**	**X^2**	**p**
Number of attacks per game	First 4 teams	4	53,156	1,68	51,8	55,5	1,494	0,28
	5.-8. teams	4	52,292	1,066	50,8	53,2		
	9.-12. teams	4	54,35	2,14	52,4	57,4		
Attack efficiency %	First 4 teams	4	58,843	2,93	55,1	61,5	6,812	0,02*
	5.-8. teams	4	53,538	3,47	49,2	56,3		
	9.-12. teams	4	50,05	3,71	46,8	54,8		

* (P<0,05)

When table 2 is examined, the assist and attack efficiency parameters of the male handball players show a statistically significant difference according to the rankings of the teams (p<0.05). Examining the group originating from this differences, it was determined that the attack efficiency parameters of the teams in the first quadrant were superior to the other teams. There is no significant difference number of attacks per game according to ranking (p>0.05).Goalkeeper parameters obtained from male handball players were examined according to the ranking (Table 3).

Table 3. Kruskall Wallis H-test results regarding the difference of goalkeeper performance parameters according to the ranking obtained from male handball players participating in the Tokyo Olympic Games.

Goalkeeper Saves Parameters	**Ranking**	**N**	**Mean**	**SD**	**Min**	**Max**	**X^2**	**p**
Saves %	First 4 teams	4	29,5	1,73	27	31	6,292	0,02*
	5.-8. teams	4	27,5	3,00	23	29		
	9.-12. teams	4	23,75	2,06	21	26		
6m saves (%)	First 4 teams	4	29,75	1,25	28	31	2,449	0,14
	5.-8. teams	4	33,25	8,34	26	45		
	9.-12. teams	4	24,75	4,27	20	30		

Wing shot saves (%)	First 4 teams	4	30,5	5,19	24	36	2,791	0,11
	5.-8. teams	4	21,25	4,57	16	26		
	9.-12. teams	4	26,25	6,65	17	32		
9m saves (%)	First 4 teams	4	42,25	6,99	34	49	0,229	0,80
	5.-8. teams	4	41,25	10,40	27	49		
	9.-12. teams	4	38,5	6,35	29	42		
7m saves (%)	First 4 teams	4	20,75	9,84	8	32	0,623	0,56
	5.-8. teams	4	13,25	6,84	7	23		
	9.-12. teams	4	15,25	12,12	0	29		
Fast break saves (%)	First 4 teams	4	19	6,92	13	29	2,282	0,16
	5.-8. teams	4	10	6,16	6	19		
	9.-12. teams	4	19	7,48	11	29		
Breakthrough saves (%)	First 4 teams	4	22,25	10,27	9	34	1,98	0,19
	5.-8. teams	4	11,5	11,50	0	26		
	9.-12. teams	4	10,75	3,59	6	14		

* (P<0,05)

When table 3 is examined, the save percentage values of the male goalkeepers show a statistically significant difference according to the rankings of the teams (p<0.05). Examining the group originating from this differences, it has been determined that the goalkeeper performance in the first quadrant are superior to the other team goalkeepers in percent. There is no significant difference according to the order in other parameters obtained (p>0.05).

Goal throws performance parameters obtained from female handball players were examined according to the ranking (Table 4).

Table 4. Kruskall Wallis H-test results regarding the difference of goal throw parameters according to the ranking obtained from female handball players participating in the Tokyo Olympic Games.

Goal Throw Parameters	**Ranking**	**N**	**Mean**	**SD**	**Min**	**Max**	**X^2**	**p**
Goal throws (%)	First 4 teams	4	63,75	2,21	61	66	3,494	0,08
	5.-8. teams	4	59,75	2,50	57	63		
	9.-12. teams	4	58	4,32	54	64		
6m shots (%)	First 4 teams	4	65,75	4,99	59	71	1,987	0,19
	5.-8. teams	4	62,25	7,27	55	72		
	9.-12. teams	4	56,25	7,84	49	64		
Wing shots (%)	First 4 teams	4	61,25	1,25	60	63	1,502	0,27
	5.-8. teams	4	60,5	2,08	58	63		

	9.-12. teams	4	46,5	23,35	14	64		
9m shots (%)	First 4 teams	4	42,75	6,65	35	51	2,702	0,12
	5.-8. teams	4	35,5	2,08	33	38		
	9.-12. teams	4	34	6,97	25	40		
7m shots (%)	First 4 teams	4	80,75	4,85	76	87	1,694	0,24
	5.-8. teams	4	83,75	10,14	69	92		
	9.-12. teams	4	60	32,53	14	84		
Fast break shots (%)	First 4 teams	4	77	7,11	67	83	0,518	0,61
	5.-8. teams	4	80	7,48	70	88		
	9.-12. teams	4	81,75	5,18	78	89		
Breakthrough shots (%)	First 4 teams	4	75,5	5,32	69	82	2,088	0,18
	5.-8. teams	4	74,75	7,63	68	85		
	9.-12. teams	4	82,75	5,05	77	87		

* (P<0,05)

When Table 4 is examined, the goal throw performances of female handball players do not show a statistically significant difference according to the rankings (p>0.05). In other words, it can be said that the goal throw performances of female handball players do not affect the ranking of the teams.

Attack performance parameters obtained from female handball players were examined according to the ranking (Table 5).

Table 5. Kruskall Wallis H-test results regarding the difference of attack parameters according to the ranking obtained from female handball players participating in the Tokyo Olympic Games.

Offensive Parameters	**Ranking**	**N**	**Mean**	**SD**	**Min**	**Max**	**X^2**	**p**
Number of attacks per game	First 4 teams	4	55,719	1,67	54	58	3,619	0,07
	5.-8. teams	4	59,458	2,81	56	61,8		
	9.-12. teams	4	56,25	1,69	54,8	58		
Attack efficiency %	First 4 teams	4	52,844	2,25	50,1	55,5	13,634	0,00*
	5.-8. teams	4	49,667	1,73	47,8	51,7		
	9.-12. teams	4	45,35	2,08	43,2	48,2		

* (P<0,05)

When table 5 is examined, the percentage parameters of attack efficiency of female handball players show statistically significant differences according to the ranking (p<0.05). Examining the group originating from this differences, it was determined that the teams in the first quadrant were superior to the other teams in attack efficiency parameters.

Goalkeeper parameters obtained from female handball players were examined according to the ranking (Table 6).

Table 6. Kruskall Wallis H-test results regarding the difference of goalkeeper performance parameters according to the ranking obtained from female handball players participating in the Tokyo Olympic Games.

Goalkeeper Saves Parameters	**Ranking**	**N**	**Mean**	**SD**	**Min**	**Max**	**X^2**	**p**
Saves %	First 4 teams	4	30,25	4,34	26	36	1,84	0,21
	5.-8. teams	4	24,5	1,29	23	26		

	9.-12. teams	4	26,5	5,91	21	33		
6m saves (%)	First 4 teams	4	29,25	6,29	20	34	0,544	0,60
	5.-8. teams	4	25,25	1,25	24	27		
	9.-12. teams	4	26,75	6,99	20	36		
Wing shot saves (%)	First 4 teams	4	36,75	5,90	31	45	0,884	0,45
	5.-8. teams	4	26,5	6,55	20	35		
	9.-12. teams	4	30,00	17,04	16	54		
9m saves (%)	First 4 teams	4	46,75	9,17	39	57	0,646	0,55
	5.-8. teams	4	40,75	3,86	37	45		
	9.-12. teams	4	44,25	8,34	34	52		
7m saves (%)	First 4 teams	4	16,00	12,67	5	34	0,747	0,50
	5.-8. teams	4	9,00	6,83	0	16		
	9.-12. teams	4	14,5	3,31	10	17		
Fast break saves (%)	First 4 teams	4	16,00	5,77	9	23	0,038	0,96
	5.-8. teams	4	15,00	5,22	10	20		
	9.-12. teams	4	16,00	6,6	9	25		
Breakthrough saves (%)	First 4 teams	4	21,75	4,11	18	27	1,98	0,19
	5.-8. teams	4	16,00	6,58	8	24		
	9.-12. teams	4	16,5	4,93	11	22		

When table 6 is examined, there is no statistically significant difference in the save percentage values of female handball goalkeepers according to the rankings ($p>0.05$). In other words, it can be said that the save performances of female handball goalkeepers do not affect the ranking of the teams.

As last finding when we look at the usage of players in rotation by the coaches, there is no statistically significant difference in this parameters of both male and female teams according to the ranking ($p>0.05$).

Conclusion

In this study in order to determine game analysis parameters that bring success, teams were evaluated in three quadrants both in women and men ranked in the Olympics.

In the evaluation of goal throws, general efficiency of shots is higher in favor of first quadrant in men. 7m throws also matched this result. This is an expected result and teams with high shooting efficiency will be successful. The fact that the shooting efficiency did not differ according to the positions showed that the position shooting efficiency of the teams participating in the Olympics was close to each other. We can generalize the same interpretation for women's matches.

General attack and goalkeeper efficiency differences are also expected results both in men and women.

All these differences show that successful teams are effective attack, goal throw and goalkeeper efficiency at all. On the other hand, about the usage of players in rotational way by the coaches is similar in all teams both in women and men. We can say that teams share the game duration with all players in Olympics.

It is essential to note the importance of the indicators established in goals scored, the effectiveness of total attacks and position attacks, total and long-range shooting efficiency and goalkeeper saves, as well as defensive actions that show significant differences between teams in relation to goalkeeper and defense (Skarbalius et al., 2013). The process of individual and collective defense actions as well as defensive match systems can become the main weapon of a team and can compensate for deficiencies in the offensive compartment (Gutierrez Aguilar & Ruiz, 2013).

Rogulj (2000) had the goal of determining which offensive and defensive collective tactics related to the duration of the match, the continuity, the systems, and the game structure that better differentiate between winning teams and losing teams. In his study, he used 27 performance indicators related to the competitive success situation of the teams. The main results revealed that winning teams were more efficient in fast transitions and individual action of progressing in attack. On the defensive end, winning teams were more efficient in executing defensive elements, and the losing teams committed several mistakes and executed inefficient shots in most of the fields' positions (Meletakos et al., 2011).

By involving a number of indicators of non-standard situational activity of the match, Foreti et al. (2013) present a contribution to defining the parameters of the situational efficiency of the players in a specific game position in handball. Understanding the importance and contribution of specific moments of the match to the final outcome can be very fruitful for coaches, in order to better perform they intervention. In this sense, individual performance indicators, such as attack efficiency, shots from the wings and 7m penalties have a tendency to be considered as key indicators of the match standard (Skarbalius et al., 2013, Foretic et al., 2013).

Analysing performance takes skill. For this reason, if correctly constructed analysis studies are supported by statistics obtained with correct numbers, the evaluation result will be magnificent.

Every handball coach wants to be able to express his team's performance in numbers one hundred percent. What will bring this evaluation closer to one hundred percent is that there are many studies on this subject.

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DECISION-MAKING OF HANDBALL REFEREES UNDER PHYSICAL AND PSYCHOLOGICAL LOAD

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Summary

In a systematic research programme, we examined the effects of physical and psychological load on the decision-making of elite handball referees. Therefore, in a scoping review, we reworked the link between physical load and referees' decision-making. Based on the review's evidence and derivations, we conducted three studies that build upon each other to examine the effects of physical and psychological load on the decision-making of top-class handball referees.
Keywords: officiating, umpire, performance, physiological fatigue

Introduction

In the highest German handball leagues of male and female competition, referees officiate about 300 respectively 200 games per season. In those games, referees blow the whistle on about 7.000 relevant occasions (7-metres, technical fouls, 2-minutes, yellow or red cards), i.e. an average of 23 whistles per game. Considering whistles and conscious absent whistles as a decision, referees make far more than 23 decisions per match. While most whistles occur at the beginning of a match, referees actively rule the game about three times at the end of a match when the goal difference is large (≥ 3 goals) and about four times in close matches (≤ 2 goals difference). If one of these few whistles is wrong, especially in the last ten minutes of a game, a team is disadvantaged and the outcome of a match may be influenced negatively by the referees rather than being determined by the teams' performances. Therefore, referees must make correct decisions at any point in a match (Bloß, Schorer, et al., in preparation).

Handball referees have to make decisions under both physical and psychological load. In this context, Mascarenhas et al. (2005) define the referees' decision-making (RDM) as well as physical and psychological capacities (i.e. to cope with physical and psychological load) as crucial constituting cornerstones of a referees' performance. Since handball matches have become faster, especially in the last ten years, referees must cope with the increased physical load (Belcic et al., 2020). Understanding RDM as a perceptual-cognitive process it can be (negatively) affected by physical load (Schmidt et al., 2019). In addition, the same referee's must also be able to cope with the psychological load during a match simultaneously (Mascarenhas et al., 2005).

In a systematic research programme, we examined the suspected effects of both physical and psychological load on RDM in elite handball. Therefore, we initially conducted a scoping review to rework current empirical evidence on the effects of physical load on RDM. Based on the review's findings, we performed two studies to research the effects of physical load on RDM. Finally, in a third study, we examined the effects of psychological load on RDM under physical load.

(1) Scoping review: Physical load and referees' decision-making in sports games:

The scoping review was conducted in accordance with the PRISMA-guidelines (Liberati et al., 2009). Eleven studies examined the link between physical load and RDM in different sports games, but none in handball.

Current evidence on aspects of physical load can be differentiated into external (e.g. running time) and internal load (e.g. heart rate; Impellizzeri et al., 2019). First, looking at studies researching the link between internal load and RDM, evidence suggests no and negative associations between internal load and RDM (e.g. heart rate, see Gomez-Carmona & Pino-Ortega, 2016; Mascarenhas et al., 2009). Second, studies examining the effects of external load on RDM as well show contradicting findings. Ambiguous results are shown, for example, on analyses examining if RDM is affected in different match periods (external load). Results differ if referees are less accurate in early match stages (Mascarenhas et al., 2009), in the second half or at the end of a match (e.g. Mallo et al., 2012). For details, please note our scoping review (Bloß et al., 2020).

Overall, the heterogeneity in methodological approaches and empirical findings of the studies included in the review rendered clear-cut conclusions regarding the link between physical load and RDM difficult. A major concern is a lack of systematically controlling the internal load as the individual reaction to an external load (Impellizzeri et al., 2019). Moreover, confounding variables such as psychological load (e.g. crowd noise; Sors et al., 2019) were not controlled since several studies used ex-post facto video analyses. Therefore, future studies should conduct laboratory studies to control confounding variables and the internal load resulting from the external load. Moreover, when researching the relationship between physical load and RDM, studies should ideally follow a naturalistic approach by simulating the actual decision-making situation as best as possible by, for example, using representative tasks and exercises as well as considering how referees actually decide (Bloß et al., 2020; Zsambok, 1997).

(2) Study 1 and 2: Global and specific decision-making of top-class handball referees under physical load

Background

While the findings of the studies included in the scoping review primarily focussed on foul/no foul likewise offside/no offside decisions, RDM in handball referees must be further specified. In compliance with the international rule book (International Handball Federation, 2016), handball referees first decide to whistle or not whistle and thus call a foul or no foul (global decision; gRDM). Subsequently, referees must decide about the type of foul (e.g. clinging) as the punishment hinges on the type of foul (specific decisions, sRDM). The latter corresponds to research indicating that referees must avoid to 'under-punish' or 'over-punish' players and thus categorization errors (MacMahon et al., 2015). Hence, in two studies, we examined the effects of physical load on gRDM and sRDM following a naturalistic approach. Considering the reworked inconsistent evidence (Bloß et al., 2020), we hypothesised that gRDM and sRDM would be affected by physical load.

Method

Participants of our studies were the top-class referees of the German Handball Federation (Deutscher Handballbund e.V., DHB). While in study 1 N = 66 referees (age: M_{age} = 31.3 years [y], SD = 3.2 y; officiating experience: M_{exp} = 11.8 y, SD = 3.9 y) participated, N = 73 referees (M_{age} = 32.1 y, SD = 6.4 y; M_{exp} = 15.6 y, SD = 5.6 y) took part in study 2; n = 59 referees took part in both study 1 and 2 (M_{age} = 31.6 y, SD = 6.3 y; M_{exp} = 14.9 y, SD = 5.4 y).

To examine the relationship between physical load and RDM, we combined the Yo-Yo Intermittent Recovery Test (Level 1, for details see Bangsbo et al., 2008) with a video-based decision-making test (video test), which we call the *Yo-Yo Test for Referees* (see Figure 1; a demonstration video can be retrieved under this link). During every second regeneration phase, referees conducted one trial of the video test instead of performing the classic regeneration phase. Referees began the video test with a fingertip on a tablet's display and then a 4-second video were shown. Afterwards, referees were displayed a decision matrix based on which they decided (1) to whistle or to not whistle (gRDM) as well as (2) about the type of foul and (3) the punishment (sRDM; for details see Bloß et al., under review). The number of correct decisions was analysed under initial, individual medium and maximum external load. To this end, we composed three blocks each containing four trials of the video test. While the same video test trials were considered for each referee under initial physical load, trials of the video test were determined individually in the middle of the test (individual medium external load) and at the end of the test (individual maximal external load). This procedure ensured that the individual endurance performance of the referees was taken into account. Running times and heart rates were measured via the Polar Team Pro System. The global and specific decisions were analysed separately by a one-factorial repeated measure ANOVA with three levels: (1) initial external load, (2) medium external load and (3) maximal external load. Please note, that in the analysis of specific decisions, only those video test trials could be included in which referees correctly decided on a foul (for details see Bloß et al., under review).

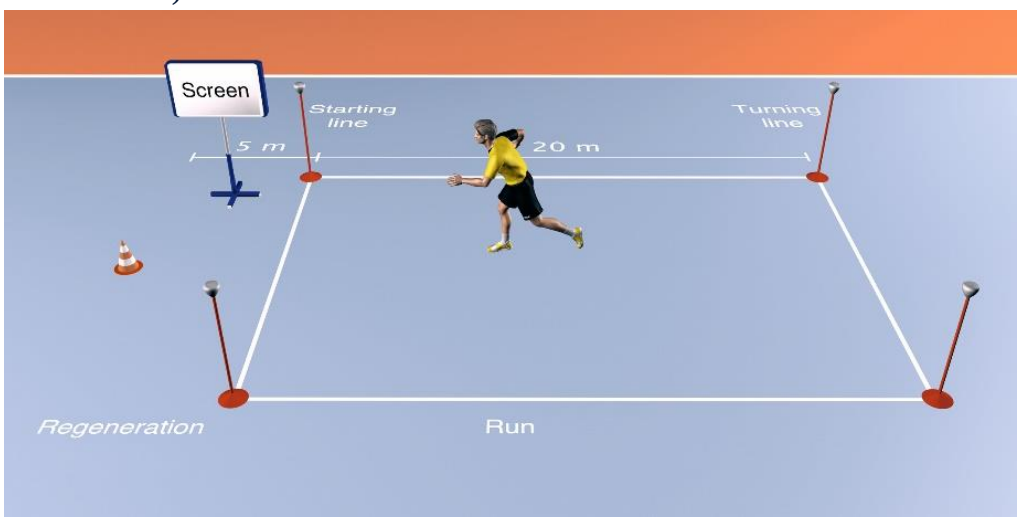

Figure 1: Yo-Yo Test for Referees.

Results - Referees' Global Decision-Making

In study 1, a repeated measure ANOVA revealed a main effect for the factor *physical load*, $F(2, 130) = 25.28$, $p < .001$, $\eta_p^2 = .28$, 90% CI [.17, .37], 1-β > .99. Referees made more correct global decisions under medium than under initial physical load, $t(65) = 6.67$, $p < .001$, $d = 0.82$, 95% CI [.54, 1.10], 1-β > .99 (Fig. 2A). The number of correct global decisions decreased under maximum physical load, $t(65) = 2.60$, $p = .01$, $d = 0.32$, 95% CI [.07, .57], 1-β = .56. In study 2, however, referees made global decisions at a higher, constant level, $F(2, 144) = 0.38$, $p = .69$, $\eta_p^2 = .01$, 90% CI [0, .03], 1-β = .11 (Fig. 2A).

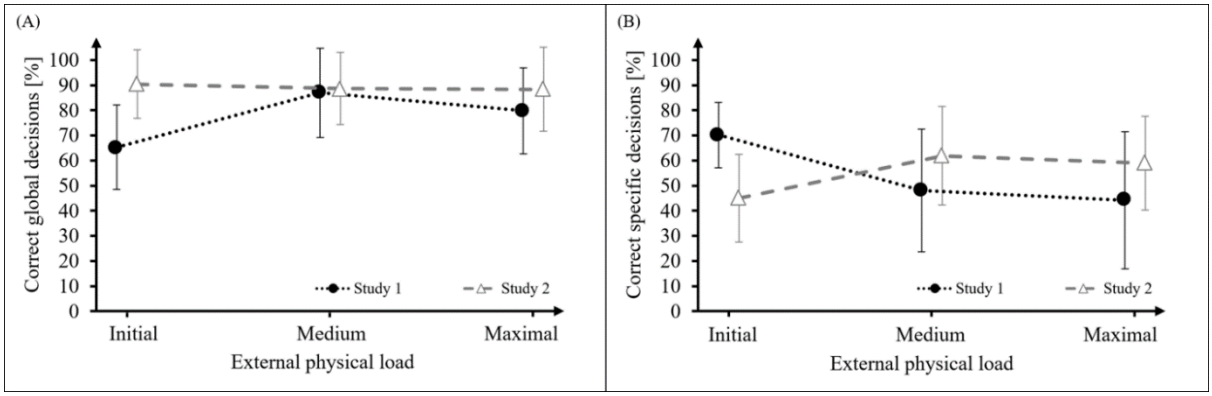

Figure 2: Mean correctness of global decisions (A, % correctness) and of specific decisions (B, % correctness) in studies 1 and 2. In all panels, error bars indicate standard deviations.

Results - Referees' Specific Decision-Making

While referees in study 1 made fewer correct specific decisions under moderate than under initial physical load, $t(12) = 2.64$, $p = .02$, $d = 0.73$, 95% CI [.10, 1.34], 1-β = .47, referees in study 2 made in turn more correct specific decisions under moderate physical load than under initial physical load, $F(1, 19) = 9.05$, $p = .01$, $\eta_p^2 = .32$, 90% CI [.06, .52], 1-β = .81. In both studies, there was a descriptive decrease in correct specific decisions from medium to maximal external load, but this was neither statistically nor practically significant (Fig. 2B).

Preliminary Discussion

Results of both studies indicate that RDM may be affected by physical load, although the direction of the effect is not consistent across studies. However, it needs to be noted that referees in study 1 ran, on average, 1.290 m (11:10 minutes), but they improved to 1.633 m (14:00 minutes) in study 2. Since an improved endurance performance has been associated with better cognitive performance and referees in study 2 made global decisions at a consistently high level as well as more correct specific decisions, we very tentatively suggest that referees should have a well-trained endurance performance (de Sousa et al., 2019). Although not conclusive based on the present studies, we propose that an improved endurance may result in lower subjective fatigue, thus enabling larger cognitive capacity, which may facilitate RDM, especially at the end of a physically challenging game (Enoka & Duchateau, 2016). As a limitation, however, referees may also have simply been more familiar with the YYTR procedure in study 2 and could therefore have demonstrated better decision-making than in study 1 (for a detailed reflection of limitations note Bloß et al., under review). As a consequence, in study 3 referees first completed four trials of the video test in the YYTR under rest and then four times in walking (5 km/h) to become familiar with the YYTR procedure.

(3) Study 3: Impact of psychological and physical load on the decision-making of top-class handball referees

Background

Referees must be capable to cope with both physical and psychological load to make correct decisions throughout a match. A central psychological load are errors made during a match. These mistakes result in increasing uncertainty in RDM, referees could get into a negative mental spiral: they start to ruminate, leading to a reduction in concentration and they are thus more likely to make additional decision errors. It is assumed that high ruminating referees, after having made one or more wrong decisions, make more wrong decisions than low ruminating referees (Poolton et al., 2011).

Method

In order to distinguish between low and high ruminating referees, N = 68 referees (M_{age} = 31.5 y, SD = 6.5 y; M_{exp} = 15.4 y, SD = 5.8 y) completed an online-based questionnaire (Rumination-Reflection Questionnaire, Trapnell & Campbell, 1999) two days after the study. To encourage referees (n = 34 each low and high ruminators) to ruminate during the study, they were given feedback on their decisions in the video test. Once they had made the decisions in the video test, they were shown a green display (if all decisions were made correctly) or a red display (if at least one decision was wrong), without being given any further information about their mistake. This was intended to stimulate rumination, especially in the high ruminating referees.

Results

Low and high ruminating referees did not significantly differ in the proportion of correct gRDM, $F(1, 66) = 1.87$, $p = .18$, $\eta_p^2 = .03$, 90% CI [0, .12], 1-β = .27 (Fig. 3A) nor in the proportion of correct sRDM , $F(1, 50) = .95$, $p = .33$, $\eta_p^2 = .02$, 90% CI [0, .1], 1-β = .16 (Fig. 3B).

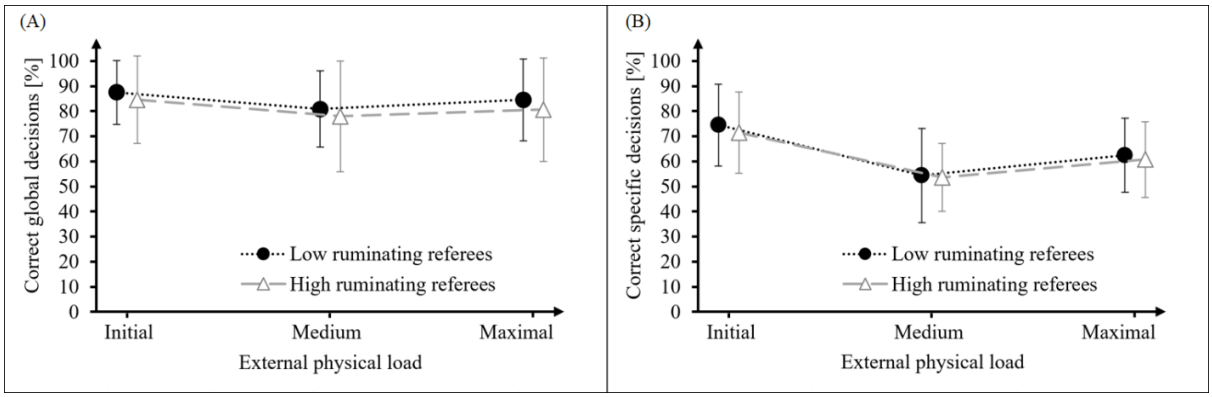

Figure 3: Mean correctness of global decisions (A, % correctness) and of specific decisions (B, % correctness) of low and high ruminating referees in study 3. In all panels, error bars indicate standard deviations.

Conclusion

Our research programme aimed to more systematically rework the evidence on whether physical and psychological load affects RDM. In a scoping review, we found inconclusive evidence on this topic and derived recommendations for future empirical studies (e.g. control confounding variables and internal load in laboratory settings; naturalistic approach; see Bloß et al., 2020).
As mentioned in the preliminary findings of studies 1 and 2, results indicate that physical load can affect RDM, which is in line with previous research (for details see Bloß et al., under review) and emphasises the relevance for referees to be capable to cope with the physical load of handball matches. However, interpretations of the findings must be treated with caution due to some limitations; for example, we cannot exclude familiarisation effects during the experiments. Nevertheless, the YYTR has the potential to become a valid and reliable tool to measure RDM under different load conditions (e.g. through the combination of physical and psychological load, see study 3). Considering as well the cornerstone model of referees' performance (Mascarenhas et al., 2005), it provides further components (e.g. psychological components) enabling to approximate to real world conditions in combination with the YYTR.
Study 3 did not reveal decision-making differences between low and high ruminating referees. One possible explanation could be the expertise of the referees: the referees whose performance is influenced by external factors could have already been excluded before the nomination for a top squad. They thus had no chance to be included in our sample, due to an insufficient performance, but without the performance-reducing factor necessarily being known (e.g. excessive rumination; MacMahon et al., 2015). On the other hand, it should be kept in mind that the psychological load induced in Study 3 was only simulated and is not comparable to actual competition demands. Consequently, under more real world conditions low and high ruminating referees might actually differ. Therefore, rumination should still be considered in addition to other psychological factors (e.g. crowd noise; Bloß, Loffing, et al., in preparation; Sors et al., 2019)
All in all, this research programme indicates on the one hand, that RDM of top-class referees is not affected by psychological load (in this case rumination). On the other hand, besides methodological limitations, it points to an effect physical on sRDM (study 1 and 2). Since study 1 and 2 show diverging results about associated effects of physical load on gRDM, however, research might further develop the YYTR to systematically rework evidence on the subject following a naturalistic approach.

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THE 20-POINT-RULE IN BEACH HANDBALL

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Abstract

This study provides a description of the results in performance of the last Beach Handball European Championship which took place in Varna between the 13th and 18th of July 2021 (EM21). Beach handball (BH) is a sport in full expansion that requires scientific studies to help its progression (Zapardiel, 2015). During a match, it is very challenging to carry out a detailed analysis that could then have a positive impact on the strategies used by coaches and improve their overall final results. Therefore, the aim of this study is to analyse the different scores on the different sets and matches, which took place in the last EM21, and define, whenever possible, the main parameters of victory and defeat that are repeated and have a pattern when we get to a certain number of points on the scoreboard.
Thanks to that, we will be able to establish a critical line in offense and defence that will determine our chances and probability to lose or win the set and, eventually, the match.
We analysed the 81 games (162 sets) celebrated in the last EM21, extracting the information from the official EHF Math Reports and the online statistics provided by the European Handball Federation (EHF) for each match. Furthermore, we complemented this data with video analysis recorded after the event using the application "XPS-Sideline Sports" to verify this study and improve the data quality.

Keywords: beach handball, data analytics, defence, offence, performance.

Introduction

We are always working towards improving the worldwide situation of Beach Handball (BH) and our final goal is for BH to be recognised as an Olympic Sport. From its beginnings until now the game has changed a lot (cf. Bebetsos, 2012; Zapardiel, 2018) which means that the trainers need to learn and follow new rules every new season, e.g., new playing styles and new challenges in the field. Therefore, is it necessary to carry out investigations and research about the development of the technical and tactical behaviour in the most prestigious European Competitions, as well as knowing the characteristics in performance of very successful National Teams. In this case, the champions were Germany for the women's National Team and Denmark (2019, 2021) for the men's one.
On average, we could see that it was easier for players to score in offensive plays rather than playing a good defence to prevent the other team from scoring. Due to a permanent 4:3 tactical skill in attack, one player should always be unmarked and, therefore, it becomes much easier to score goals and success when trying to score is guaranteed (Fasold, 2019).

The current study showed that there is actually a correlation between the number of goals scored against you and the number of goals scored by you. This proves how the defence in BH can hold the whole team in one set. We need to take into consideration that the offence needs to keep the score higher than the opponent by a certain number of goals, if they want to win the set. It is also critically important to verify if a certain number of goals scored by the offence will provide us, on a higher percentage, with the victory in that set, even though the goals conceded on the scoreboard are, on average, higher than the trend.
The same happens with the defence as teams need to keep the goals scored against them lower than their opponent by a certain number of goals if they want to win the set.

In order to improve the overall performance, the different possible scenarios must be known to design specific training. Therefore, video and data statistical analysis provide coaches with accurate information to set up routines and goals to work on during the different game phases.

Methodology

In this study, a quantitative video analysis was conducted and included the following data: 81 games of the EM21, together with the European Handball Federation Match Reports and, the Online Statistics provided by the EHF (thirty-two preliminary round games, eighteen main round games, six consolation round games, ten cross matches for places 5th to 16th, four quarterfinals, two semi-finals, one consolation final and the final).
The data analysis includes all the participant teams in the EM21. Some National Teams played 1 less game (Croatia, Poland, Sweden, Bulgaria, Russia, Portugal, Germany, Netherlands), due to the setup of the preliminary round groups.
For each game, we identified and differentiated the following categories; court, home team name, away team name, total result (1-2, 2-0, 2-1), results in the 1st set, results in the second set, shootout results, first set results for the home team, first set results for the away team, second set results for the home team, second set results for the away team, home shootout results, away shootout results and round of the game. After collecting the previously mentioned data, a table like the one below was created for each team:

Round	Opponent	Offense 1st set	Defense 1st set	Offense 2nd set	Defense 2nd set	Shootout offense	Shootout defense	Average offense	Average defense
Preliminary Round	Romania	24	11	22	13			23	12
Preliminary Round	Turkey	21	14	23	18			22	16
Preliminary Round	Norway	24	18	19	16			21,5	17
Preliminary Round	Spain	23	18	19	16			21	17
Main Round	Hungary	17	14	20	21	7	6	18,5	17,5
Main Round	Ukraine	30	10	23	11			26,5	10,5
Main Round	France	22	14	23	7			22,5	10,5
Quarter Finals	Portugal	17	10	15	14			16	12
Semi Finals	Russia	16	18	19	16	8	6	17,5	17
Finals	Croatia	25	20	28	22			26,5	21
Average Total		21,9	14,7	21,1	15,4			21,5	15,05

Figure 1: Example of a table with the information regarding Denmark's National Team which analyses the development of the Danish National Team during the different rounds, sets and

opponents. The average number in offence and defence for the entire tournament and the shootout results in offence and defence are also displayed in this table.

Following the previous figure, each National Team set results was split (Figure 2).
On an X/Y chart, the number of goals received in defence (x) and the number of goals scored in offence (y) was split by separating each set and each opponent. The teams are mostly situated in the lower right corner and, just in 2 occasions teams scored more than 20 goals in offense.

Results

Across the 162 sets in the 81 games analysed, the average number of goals in defence and offence is 19.5 goals and 27% of those 81 games (n=22) were settled in Shootouts.

On the one hand, a total of 66% of the sets (n=107) finished with results of over 20 points in offence and, on the other hand, a total of 34% of the sets (n=55) finished with results of under 20 points in offence.

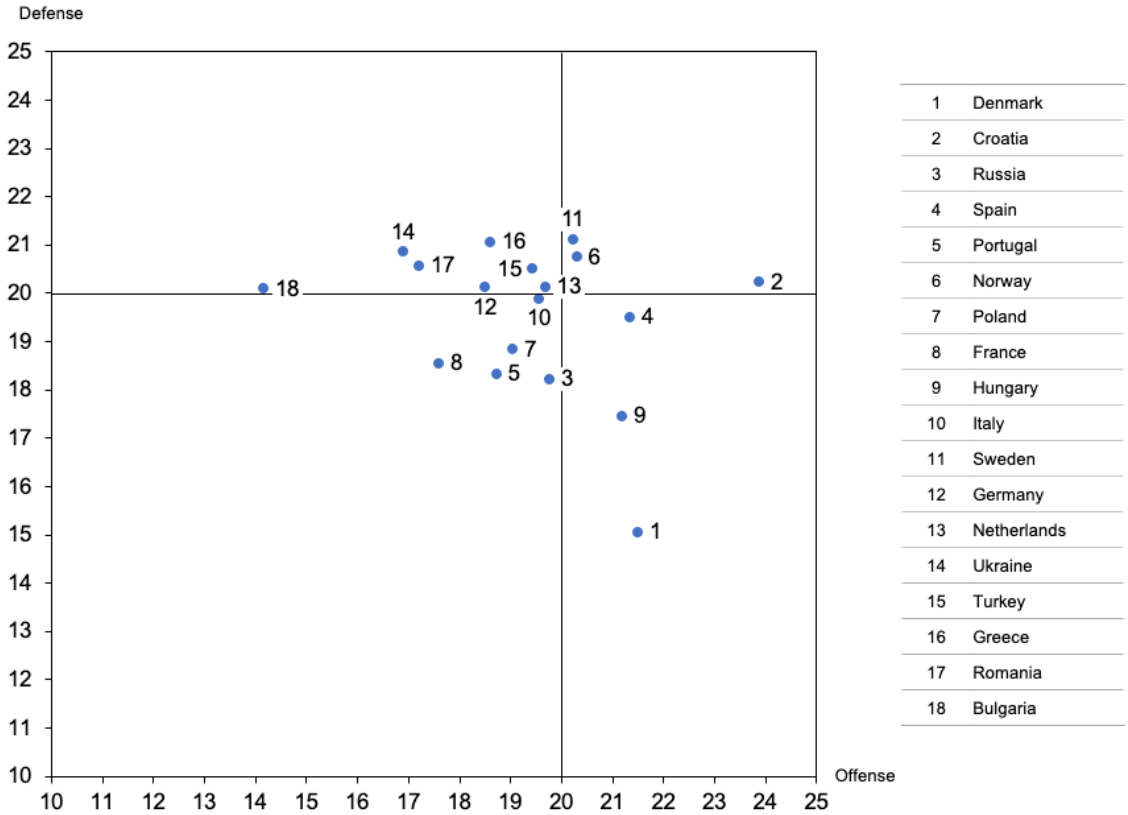

Figure 3: Distribution of the team score averages split between defence and offence according to the 20-point-mark.

Following our previous examples with the Danish National Team, the averages of the defence and offence are benchmarked for all the other National Teams. Average in defence is 15.1 (best defence average) and the average in offence is 21.5 (2nd best offence after the Croatian National Team).

Although Croatia is ranked 12th in best defence, the overall success relies on the outstanding performance in offence, with an average of 23.9 goals per set (best offence).

The highest-ranking teams appear close to the lower right corner in the graph (Croatia, Russia, Spain and Denmark).

The most interesting outlier in this study is number 9 (Hungary) as their game statistics are comparable to a semi-finalist team, but they did not actually manage to go any further. Except for the Hungarian National Team, the four semi-finalists are higher up in the ranking when it comes to either defence and/or offence, which can be extracted from Figure 3.

The following curve that shows the distribution of scores in the EM21 after analysing the different results obtained by the winners and losers. We will be able to see the chances a team has to get one victory according to the highest score value.

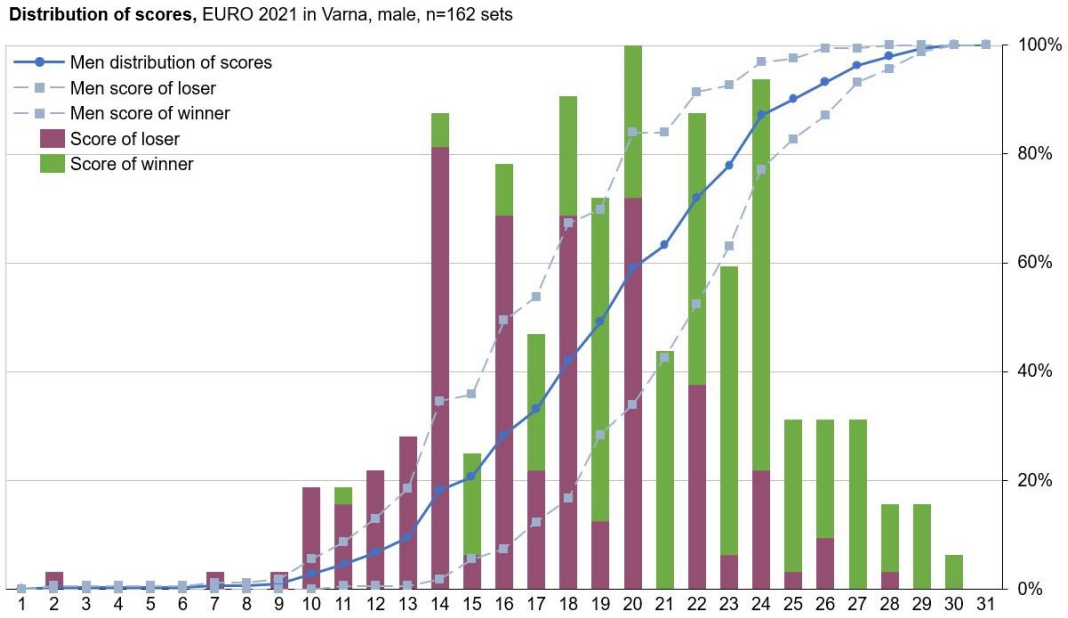

Figure 4: The blue line defines the Global Distribution of scores. Above that line we may see the loser's distribution line and, below the blue line we may see what we defined as a winner.
The first losers line starts on the 2 points on the scoreboard (Ukraine against Hungary) but not winning team with 2 points. Therefore, we may see the first winner set with 11 points on the scoreboard (Portugal against Poland).
We may also see that, once the 20-point-mark is surpassed, the losers' score decreases significantly, clearly establishing that after this 20-point-mark, the probabilities and chances of winning increase.

In Men's teams, there is no register of any defeat when the score is exactly 21 goals in EM21.

An element to highlight in the EM21 was the equality of the contending teams; on the one hand, 52% of the results (n=82) where settled with 4 or fewer points. On the other hand, 48% of the results (n=80) where were settled with more than 4 points.
Analysing the results thoroughly and watching the losers' line in the graph, we may see that 85% of the losers scored 20 or fewer points. In regards to the global distribution line, we may see that 60% of the teams scored 20 or fewer points. Finally, taking a look at the winners' line, we may say that 36% of the winners scored 20 or fewer points.

Regarding Offence (Figure 5), on the global average during the EM21, the probability to score more than 20 points is 66% in offence. However, the reality is that less than 34% of the winners' offence scored less than 20 points. In other words, 66% of the winners' offense scored 20 or more points.
On the other hand, regarding Defence (Figure 5), on the global average during the EM21, the probability for the other team to score 20 points or less against your team is 34%. However, the reality is that approximately 84% of the winners' defence conceded 20 or fewer points. In other words, 16% of the winners' defence conceded more than 20 points.

Conclusions

Gathering all the information into one table will allow us to clearly see, the different chances that a specific event occurs in the EM21. These events below must not be a rule, they ought to be considered indicators that allow us to see where to start from and the needs we have to take into consideration when comparing future results to the current ones in the next European Championship.

		Defence		
	POINTS	**20 or fewer**	**>20**	
Offence	**20 or fewer**	34%	0%	34%
	>20	50%	16%	66%
		84%	16%	100%

Figure 5: The table represents the likelihood of these events occurring after reviewing all the previously mentioned sources and data. We may state that if your team scores more than 20 points and concedes fewer than 20, the probability of winning increases to 50%. This means that, in 50% of all games, the winners score more than 20 points and the losers score 20 or fewer points, so the rule applies to them. Therefore, in 84% of the games, the winners defence does not get more than 20 points scored against them. Consequently, the remaining 16% are the unlucky losers as in 16% of the sets, the team scored more than 20 points but still did not win the game. It is still important to mention that we have seen results outside this rule. For example, a team with a scoreboard of 20 or fewer points in offence that managed to win or a team with a scoreboard of 20 or more points in defence that was still defeated, as the table shows.

The different styles in team tactics, for example the Croatian National Team with its high speed in offence and the Danish National Team with a very powerful and well-performed defence can be proven with the analysed data. Both teams are above average in offence, but only Croatia is above the 19.5 average in defence. As a conclusion, we may say that the combination of offence and defence from Denmark made them champions and, for Croatia, their offense outperformed all the other National Teams, making it extremely difficult to defeat them. As we already mentioned before, from its beginning until now, the game has changed a lot (cf. Bebetsos, 2012; Zapardiel, 2018). As a discussion topic, we can certainly agree that the speed of the game trend is different in each country, compared to the speed of the games occurring in the different European Beach Handball Tour (EBT) or in EM21 for International Male European Competitions. This difference in speed would result in more points in the scoreboard in the offence and defence in each country.

It is a well-known fact that a universal rule regarding defence and offence tactics does not exist, however, we consider it necessary that coaches choose alternative tactical strategies taking into account the previous European Competitions with this data analysis and therefore combining the coach tactical strategies with knowledge and understanding of their opponent performance.

These conclusions are also limited to the time and place of the EM21 as these studies might vary due to the changing nature of how the rules are implemented by referees and also due to further BH development and tactical trends. Further studies need to be carried out after every European Championship or European Beach Handball Finals to see the progress of this study and how the speed of the game or any changes to the nature of the rules apply to the 20-point-rule in Beach Handball.

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RETHINKING HANDBALL TEACHING AT SCHOOL TO SUPPORT INCLUSION AND STUDENT DIVERSITY

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Summary

This study aims to explore how PE pre-service teachers implement, conceptualize and perceive handball teaching at school, during covid-19, with a greater focus on fostering less skilled students, active participation and game play accessibility. Four PE pre-service teachers were interviewed about the value and perceived effectiveness of the used methodology to create a learning environment for all.

Keywords: Physical Education, Pre-service Teachers' Voices, Learning, School Placement.

Introduction

The UNESCO (2015) guidelines for Quality Physical Education (QPE) highlights the inclusive potential of PE focused on allowing access, participation, and achievement in the domains of physical literacy, civic engagement, academic achievement, social inclusion, gender equity, and health and well-being. Handball, as other team sports, can be used in Physical Education (PE) to develop cooperative skills, engage in relationships with others, learn to cope with winning and losing, and to provide fun and joy in the game. However, when scoring and winning are the only focus of the students, the solidarity, respect, tolerance, inclusion and fair play values might be at risk. Game play and competition in PE should be practiced in striving together, to initiate the students towards inclusive and respectful ways of playing. In addition, students benefit from competitive PE environments to be motivated to learn the skills and be involved in the activities. In order to explore the potential of QPE, it is necessary to ensure the place of PE in the core curricula, to encourage inclusive and innovative approaches, and to invest in teacher education and professional development. Therefore, PE teachers need to experience evidence of the benefits of inclusive practices by training, school support, and university collaboration through in-service and preservice inclusion-oriented programs (Florian & Linklater, 2010, Florian & Rouse, 2009; Korthagen, Loughran & Russell, 2006; Penney, Jeanes, O'Connor & Alfrey, 2018). But, what does inclusion mean in the context of handball at school? Moreover, most importantly, how can PE teachers create an inclusive handball learning and game play environment that benefits all students, no matter what their performance level and needs?

Academics in handball teaching in a school environment have long voiced their concerns at the persistence of traditional teaching and instructional approaches that are predominantly technique-centred and teacher-directed. At Porto University, the PE teachers preparation are based on game-based approaches (Estriga, 2019) and pupils-centred in nature. Therefore, this approach demands educating knowledgeable and "thinking" future PE teachers, able to find and try solutions to real practice problems and pupils' needs, instead of a reproductive style: "do as I do". Such challenges and goals demand a new pedagogy in terms of PE teachers' preparation, grounded in contemporary theoretical knowledge, practice experience and research.

The handball game-based approach developed in Porto University places a greater focus on game problem-solving and guided discovery to improve pupils' game sense and playing skills. Such conceptions emphasize the need to modify the game with constitutive rules, understandable and playable by every player from the very beginning, without discrediting its internal tactical logic. In this regard, sequential and interlinked game forms, with increased complexity, are proposed and taught to inform PE teachers about how to design and implement handball-teaching units.

The game-based approaches demand accommodating individual differences in the game configuration and learning tasks. Therefore, removing impediments to access and active participation in the game play by every student from the very beginning is essential. This requires adapting game rules, playing roles, action boundaries, and scoring goals, in order to accommodate gender, physical characteristics, motor, cognitive, emotional, social, and cultural differences, which impact on play interaction.

Knowing how PSTs subsequently try to implement the addressed teaching approach and instructional strategies to deal with student diversity and support inclusion in PE classes may provide useful insight for PE program preparation improvement. Attending to this scenario, this study explores how PSTs implement, conceptualize, perceive and value the varied aspect of handball teaching at school, during Covid-19, with a greater focus on instructional strategies to foster less skilled students' active participation and game play accessibility. The specific objectives to achieve this aim were:

1) Identify the measurement and strategies to deal with Covid-19 during the PE classes;
2) Analyse PSTs tried methodologies and strategies to teach handball and to deal with student diversity;
3) Explore PSTs perceptions about the effectiveness of the tried key-instructional strategies to deal with student diversity and for inclusion in handball:
4) Capture the value that the PSTs ascribe to teach handball attributed to the experience.

Methodology

A qualitative descriptive methodology was used, in order to exploit and gain deep insight into the complexity of the teaching-learning in team sports through studying individual PE PSTs experience and how sense is made of theoretical knowledge (through formal and informal sources at the university), of practice experience and actions during the classes. As stated by Lambert and Lambert (2012), a qualitative descriptive study is a comprehensive summarization, in everyday terms, of specific events experienced by individuals or groups of individuals.

Participants and context

Four PE PSTs from a two-year Physical Education master's degree programme from Porto University took part in the study. The first year of the programme takes place at the university and focused on general educational subjects and Specific Sport Didactics, such as Handball Didactics. During the second year of the programme, PSTs work with their university supervisors on Mondays at the university and during the entire academic year (school placement) with their school cooperating teachers.

PSTs were purposefully selected (Patton, 2002) according to (i) they had the opportunity to teach handball at school, despite the Covid-19 constraints, (ii) their availability/interest in joining the pedagogical experience, (iii) undertaking school placement in schools where cooperating teachers were interested in being involved in the project.

The study purpose and design were explained to each participant and it was made clear that they could opt to leave the study at any time without any consequences and all signed an informed consent form; pseudonyms are used to indicate their opinions (Mark, John, Brian and Peter).

All the PSTs teach secondary classes. Mark and Peter used distributed planned teaching contents with the other two using block Teaching Units. The number of teaching sessions and their duration to teach handball also varied, with Pedro having 14 sessions, Brian 6, John 15 and Mark 20. All their classes were supervised by the local Teacher-Educator.

Data collection and data analysis

Data was collected through semi-structured interviews with the selected participants, conducted by an experienced researcher into this methodology. A semi-structured interview script was used in order to capture PSTs perspectives, value and meaning of teaching handball in an inclusive way at the school placement (e.g., *What was the experience of teaching handball like? What critical events do you identify with? What challenges, difficulties, achievements?'; 'What dynamics did you try to implement in classes? What instructional strategies did you use and why?'; 'How did you try to respond to the different needs of students? What strategies worked best?)*. The interviews were transcribed verbatim and participants were allowed to check the transcriptions. A deductive-inductive analysis procedure was used across data, moving back and forth between the objectives of the study, the data and the notion of inclusion and student diversity. Data analysis used a three flow activities: data condensation, data display, and drawing conclusions (Miles et al., 2014), with the researcher oscillating between the three activities. Resulting from this process, four main themes were identified: (1) measures and strategies adopted to fight Covid-19 during the PE classes; (2) challenges and strategies to deal with student diversity and to support inclusion, (3) student learning, and (4) the value of the teaching experience for the PSts.

Results

Measures and strategies adopted to fight Covid-19 during the PE classes

In order to reduce the potential transmission of the virus, mandatory use of face masks during the practice was adopted by Mark and John and the others recommended its use, even in open spaces.

> *"In the first lessons, some students removed the mask under certain circumstances but, after a while, they got accustomed and stopped removing it."* (Mark)

All the PSTs mentioned having adopted the concept of the bubble; the class was divided into several groups comprising a small number of students, who would remain together during the whole lesson or several lessons. When using any type of game situation, all four agreed that the groups constituted a few players each, with no switching between them being allowed, and attacking numerical advantage was used to provide some distance between players. The handball lessons were more focused on technical abilities to avoid close contact between students.

> *"(…) if I made that group of three, for example, that group remained together until the end [of the class] with the same ball to avoid any mixture.* (Peter)
>
> *"We had to avoid contact situations and choose activities more focused on technical skills".* (Brian)

Another consequence of the need for class control was that decisions were all teacher-centred, even in the constitution of the groups.

> ***"****Students did not have autonomy to choose the elements of their groups". (*Mark)

Challenges and Strategies to deal with student diversity and to support inclusion

Challenges

All the PSTs said that one of the most challenging tasks was how to meet the needs of different learners in their classes, as there was a huge heterogeneity in terms of performance and motivation to practice, which seems to be more problematic among girls. Two pre-service teachers mentioned that it was quite difficult to involve some girls in the game action and learning tasks. Brian gave an example of how he tried to change this lack of initiative:

> *"But, then, there were, for example, the girls who were more static, waiting for things to happen, and, if there was no stimulus from the teacher for them to interact in the game, they would pass the ball without doing anything".*

Another challenge was getting out of the technical approach and engaging the less skillful students in a more game-based approach:

> *"To move away from the technicist approach towards an approach based on tactical understanding, putting the more skillful students helping those who have more difficulties was a great challenge".* (Brian)

Strategies

The strategies used were multiple and of a different nature. The game format, rules of the game, action boundaries, and ability-based group strategy were recognized by all the PSTs as essential instructional tools to encourage participation of less skillful students into game play. The use of tailored balls (such as the *Goalcha balls*) was also recognized as a successful strategy that allowed the less skillful students to achieve the goals of the proposed activities.

The Game format, such as offensive numerical advantage with few players, provides more space-time and opportunity to make decisions and to act with confidence. This strategy, and because of Covid-19, game forms based on offensive numerical advantage were mostly used, which was created by using an extra attacker that could play for both teams or instructing the goalkeeper to act as a court player in the attacking phase. While Mark and John reported to have used the same game form during the whole unit, the other two had the opportunity to introduce more advanced game formats. Brian mentioned:

> *"I tried that the game format not change from lesson to lesson. I only thing that was added was to give more autonomy to the students, so that they could decide to play with or without the pivot."*

The modified scoring rule, the same player is not allowed to score twice in a row and the first match goal of each player counts for two or three points (two- or three-point shot), was perceived as useful to provide less skilled students with shooting opportunities, but it seems not to solve the lack of shooting skills *per si.*

> *"The 2-goal shot didn't work very well because they continued to have difficulty in finishing, and, even so, they tried (...). The strategy of the same player not shooting twice in a row, in this case, worked very well and made the game more balanced, and we saw a team playing and not an individual".* (Peter)

The action boundaries, such as to constrain the bouncing usage and that everyone must touch the ball before finishing, were seen as effective strategies to boost a more cooperating game, leading to more inter-passing actions.

> *" (...) there were times when it was mandatory to pass the ball to everyone before finishing; the same student could not finish 2 times in a row; the one-bounce rule also helped ball circulation, that is, rules that made participation for all, which was for those with less ability not to stay close to the goal area line without ever receiving a ball.* (Peter)
>
> *The ball must go to everyone before a goal attempt takes place. You guys, now, must pass the ball from one side of the attack to the opposite side before shooting (...) or ball circulation twice.* (Brian)

Peter adds that, to challenge the best players and, at the same time, regulating the game, those players could only pass and shoot with the non-dominant hand.

The ability-based group strategy was used for two of the PSTs while the others used the Sports Educational Model, with the class divided into teams with a heterogeneous composition, but balanced, and being instructed to work together to prepare for the inter-class competition.

Mark mentioned that he felt useful in trying different strategies or solutions to support inclusion and to adapt the process depending on the daily observations. So, he considers that the ability-based group approach allows for different learning needs and tasks, even when using a similar task in different performance level groups that allows the adjustment of the opposition, and to easily introduce rules, actions constraints or variants according to each group's difficulties and needs.

> *To create rules, stimuli or variants so that students could all be in the same activity or working in groups and, within these groups, they might have identical or different levels of performance, depending on the activity. And it was these things that made the most impression on me.* (Brian)

During the same task, sometimes, the groups were working on different things because the difficulties are different. I used an on-going adaptation process and always tried to have varied strategies in the class, that is, the two groups were separated, but then, if necessary, in the next task, they were all mixed up. (Mark)

Brien sees advantages in changing the composition of the groups during the classes, and explained how he managed different groups' needs to boost more teamwork:

"I also changed the groups so that they didn't get used to a certain type of inter-action and to have the greatest possible experience, so to speak, so that they don't always have the same teammates/opponents, so that they don't always have the same opponents, so that they don't become fully comfortable."

Also, Brien explained how we manage different group needs and gave an example of an action rule used to promote more teamwork:

"A very competitive student who didn't like to lose, and if this happened, he would get excited, but he managed to understand the reasons for those modified rules (for inclusion) and started to help teammates to overcome their difficulties, leading them to start having more balls, to trust more and, I think, everything would be fine."

Regarding the attributed roles to students during the classes, all PSTs mentioned having often involved the students in refereeing tasks and only Peter used other roles.

"(...) different roles: coach, referee, captain – what worked best was captain." (Peter)

And Brian adds that during matches:

"When there were players waiting for their turn to play, they were given other types of working tasks, such as dribbling."

Concerning referees, all the PSTs identified student difficulties in assuming this role:

"I noticed that some students had difficulty in imposing themselves; they realized it was a foul, but were afraid to say it or not say it out loud and the others continued the game and didn't want to know what the referee was saying." (John)

Only Brian had the opportunity to use the tailored/soft handballs (*Goalcha balls* size 0) during a short handball unit with a class of 11th grade (20 girls and 8 boys). About half of the students presented a low level of game skills and physical fitness. According to Brian's opinion, soft balls have several advantages, namely: enhance teamwork based on ball exchange, improve game flow, with fewer game interruptions caused by missed pass receptions, empower less skillful players (and girls) to more active and effective participation in game actions and provide more protection to the goalkeepers, as, when a ball hits he/her, it doesn't hurt. Another huge advantage is that this type of ball promotes cooperation because it discourages dribbling.

"(...) it is an advantage because it inhibits dribbling leading to greater teamwork, so they feel the need to pass the ball, discover a safer passing lane, and to free themselves to support the ball carrier, thus giving greater fluidity to the game."

This type of ball also seems to improve pass reception success, helping to develop confidence between the passer and the receiver. As Brian noticed:

"(…) *And talking about the girls, they can catch the ball more easily."*

As a disadvantage, Brian mentioned that a bounce pass is more difficult to perform, particularly when passing to the pivot.

Student learning

The PSTs noticed that, when students understood what the goal of the tasks is, they became more involved and were more successful.

> *"When they realized why, or for what, or what we intended, what was possible to be done, then, their involvement was better".* (Brian)

The transition from numerical superiority to numerical equality was considered successful in Peter's class:

> *"That's why one of the goals was to reach numerical equality and it was well achieved because I think they [the students] managed to play in numerical superiority with quality and with the principles that were proposed to them."*

All the PSTs identified improvements in team dynamics and interactions between students during the competition.

> *"In the last games (...), it was remarkably different. The relationship between the team itself evolved, there were also some more negative behaviour in the competition, which happened in the first classes and were resolved over time; that is, another objective was to try to mediate, control the behaviour of students in competition and I think, at the end, that was achieved; the last competitions went better than the first ones."* (Peter)

The value of the teaching experience for the preservice teachers

Despite the pandemic situation, all the PSTs reported that their handball teaching experience was very positive.

> *"In general, I think it went well, despite being in a pandemic."* (Peter)
> *"I liked it, I liked it a lot. I think it was too short, it could have been more fruitful (...) and I stuck to a very basic form of play."* (Brian)

The theory-practice relationship was highlighted by the PSTs as a significant learning experience.

> *"(...) in general, it was good to teach handball because I was able to gain more knowledge and what I had already learned in the handball didactics at the faculty (...) I was able to understand what works and what doesn't work in practice (...)."* (Peter)

The construction of the didactic unit in a follow-up process was quite valued by Peter.

> *" I liked the structure of the didactic unit because, due to this simplicity, it was very easy to acknowledge: what is the objective in today's class? What are the exercises? Is there any role to be applied to the students?", that is, everything was articulated in a very simple way (...)"*

On the other hand, Brian says that this experience made him see the teaching of handball in a different way:

> *"The balance is extremely positive because, first, it made me see handball teaching in a different way; second, I emphasized things (...) at the level of knowledge".*

Final Remarks

The main purpose of this study has been to contribute to the discussion about how to address the different learning needs of students with distinct handball game skills and performance levels, by analyzing PSTs' perceptions about the tried instructional strategies and whether it had the intended impact on student learning and inclusion. Despite the contextual class differences and Covid-19 limitations, the PSTs' discourses allowed the conclusion and valued the experience, that they were able to relate the game-based approach and key instructional strategies taught at the university with real practice. The findings pointed the effectiveness of the main key instructional strategies for inclusion; however, the reported difficulties and challenges also raised the need for more supported practice experiences regarding the ways to answer diverse game problems and skills that students need to learn by improving their participation in the game actions.
Further insight and research are needed to investigate teaching approaches and key instructional strategies allowing for the creation of a more intimate, meaningful game play environment for all, especially for low-skilled students.

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HANDBALL COACH TRAINING STRESS RESPONSES: A PRELIMINARY STUDY

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Summary

The study revealed several important findings; 1) handball training similarly influenced AA and HR dynamics – raising throughout the training and decreasing after, 2) Cortisol levels significantly decreased throughout the training, 3) results of all measured markers returned to normal values 90 minutes after training finished, 4) average results and standard deviations of STAI indicate a similar level of stress during different training sessions and relatively low anxiety level during the training session. Results of this study confirmed the expected stressful character of the handball coach job during training.

Keywords: cortisol, alpha-amylase, biomarkers, heart rate, anxiety

Introduction

Coaches must play multiple roles and endure the technical, physical, organizational, and psychological challenges in their jobs. There is no doubt about the stressful nature of sports coaching (Fletcher & Scott, 2010). Coaches' performances (and future employability), are often judged by the success of their athletes (Gould et al., 2002), especially during training sessions that represent significantly the largest part of coaching work. Often coaches encounter a large amount of stress that is the product of different expectations from different sides that deepened on coaching success; fans, athletes, parents, media, team management, etc. (Olusoga et al., 2009). In team sports games stress is even more enhanced cause of numerous social interactions that appear between team members, players and coaching staff.

To endure stressful surroundings, and find effective strategies for dealing with them, it is important to monitor the level of stress that the coach experience during the training and the competition. The majority of studies that dealt with this issue used interviews or questionnaires as the main tool (Olusoga et al., 2009; Rumbold et al., 2018). This approach is adequate for measuring general but not sufficient for measuring actual stress that is occurring just before, during and immediately after the training or competition.

Several studies reported that various types of psychological stress activate the hypothalamus-pituitary-adrenocortical system (HPA) and consequently induce substantial increases in salivary cortisol levels (Takai et al., 2004). Alpha-amylase is a major salivary enzyme and is secreted from salivary glands in response to sympathetic stimuli (White & Averner, 2001). Levels of salivary cortisol and salivary alpha-amylase have been used as stress biomarkers (Rai et al., 2011). Because these biomarkers can be sampled noninvasively and fast they are an acceptable tool for measuring acute stress of sports coaches.

Handball is one of those team sports games in which coaches endure significant stress. Contact nature of the game, a large number of matches and players that interact with the coach multiply stressful situations for handball coach. Thus, the main goal of this study was the determination of handball coach psychophysiological responses to training by obtaining; stress biomarkers (salivary C and AA), heart rate dynamics and anxiety inventory (STAI). Specifically, to compare physiological and psychological data before, during and after training stress appear.

Methods

In the study participated just one professional handball coach, age 37. Participation in this study was voluntary. stress was monitored before, during and after 5 handball training sessions. To establish normal circadian rhythm values of stress biomarkers (C and AA) coach spent 1 day fasting without any physical activity in his apartment. During this day from 9:00 am till 9:30 pm 10 samples of his saliva was taken. In the second part of the study, stress markers were monitored before, during and after handball training. All 5 training sessions were held in the same hall (QHA sports hall) for 7 days. The training schedule varied between 4:30 pm and 8:30 pm. Training stress was measured with salivary cortisol (C) and alpha-amylase (AA) concentrations, heart rate (HR) and with State-Trait Anxiety Inventory.

Saliva samples were collected in 5 time points 20 minutes before the training, at the middle of the training, directly after the training, 45 and 90 minutes after the training. Coach avoid eating a major meal 60 minutes before sample collection, rinsed his mouth thoroughly with water 10 minutes before each sample was collected. For this purpose, SalivaBio Oral Swabs - SOS (Salimetrics LLC, State College, PA, USA) were used, placing them underneath the tongue on the floor of the mouth for 2 minutes. After collection, swabs were placed into a storage tube and were refrigerated immediately. Within 2 hours following sampling, samples were frozen at below -20°C until centrifugation. On the day of analysis, samples were thawed completely and centrifuged at 1500 x g (3000 rpm) for 15 minutes. After centrifugation, assays were performed. Saliva cortisol and alpha-amylase were analysed with a commercially available enzyme-linked immunosorbent assay (ELISA) purchased from Salimetrics LLC (State College, PA, USA) on a microplate reader (Infinite 200PRO, Tecan, Mannendorf, Switzerland). All samples were analysed in the same batch to avoid interassay variability.

Heart rate was measured by a heart rate monitor that the coach wore 4 hours: 30 minutes before and 90 minutes after the training (Polar M430, Finland).

Coach emotional state was measured with the State-Trait Anxiety Inventory (STAI) which he filled directly after training finished. STAI is an instrument that quantifies state anxiety and includes 20 questions that indicated how the participant felt at the moment he was filling the inventory. These questions are answered based on a 1-4 scale, with the focused areas including worry, tension, apprehension, and nervousness. The result is presented as a score (Spielberger, 2010).

Statistical analysis included calculation of descriptive statistic parameters while normality was tested using the Kolmogorov–Smirnov test procedure. T-test was calculated to evidence differences between levels of salivary biomarkers and heart rate. The software Statistica ver. 13.0 (Dell Inc, USA) was used for all analyses.

Results and Discussions

Table 1. Results of descriptive statistics

Variable	N	Mean	SD	MIN	MAX	Max D	KS p
HR 1	5	75.24	71.83	80.25	3.99	0.31	p > 0.20
HR 2	5	90.86	81.62	104.45	8.89	0.20	p > 0.20
HR 3	5	91.02	85.79	96.85	5.00	0.24	p > 0.20
HR 4	5	75.84	72.41	79.77	2.94	0.17	p > 0.20
HR 5	5	67.22	62.08	70.38	3.25	0.26	p > 0.20
C 1	5	0.18	0.16	0.22	0.02	0.21	p > 0.20
C 2	5	0.15	0.12	0.17	0.02	0.22	p > 0.20
C 3	5	0.11	0.09	0.14	0.02	0.24	p > 0.20
C 4	5	0.13	0.09	0.16	0.03	0.21	p > 0.20
C 5	5	0.10	0.01	0.22	0.07	0.23	p > 0.20
AA 1	5	39.52	25.21	47.82	8.72	0.29	p > 0.20
AA 2	5	55.45	29.37	65.68	14.99	0.36	p > 0.20
AA 3	5	56.21	44.92	68.19	10.51	0.24	p > 0.20
AA 4	5	47.53	38.24	56.58	7.19	0.21	p > 0.20
AA 5	5	26.99	23.06	32.23	3.60	0.18	p > 0.20
STAI	5	28.8	2.28	27	33	0.23	p > 0.20

Legend: HR-heart rate. **C**-cortisol. **AA**-alpha amylase. **1**-before training. **2**-in the middle of the training. **3**-imedietly after the training. **4**-45 minutes after the training. **5**-90 minutes after the training

Table 1 shows the results of descriptive statistics. Although the sample consisted of only 5 cases all variables showed normal result distribution and were suitable for parametric statistical analysis. Figure 1 is presenting the stress markers dynamic that coach endured through the handball training sessions. These dynamics are more precisely described in table 2. Table 2 shows the results of differences between 5-time points of measurement. Heart rate (HR) rose from the beginning till the end of the training. It never exceeded 92 beats per minute. 45 minutes after the training it came to pre-training values while 90 minutes after the training it came to the normal level (67.22 beats per minute). HR values were significantly different before, in the middle and directly after the training. This points to the relatively low physical activity of the coach during the training session and HR as a more reliable indicator of coach physical rather than psychological stress. Although, HR is sometimes considered to be connected with negative emotions and stress (Behnke & Carlile, 1971; Dishman et al., 2000), as, in our study, most of the researches of coach's job refer to other indicators of stress (Fletcher & Scott, 2010; Olusoga et al., 2009). Cortisol (C) values were the same before the training as on baseline testing in the same hour (0.18 vs. 0.18). The C level

significantly decreased at the middle of the training (0.15) and after the training (0.11). In baseline testing, the C level was also gradually decreased from 0.23 in 16.00 hours to 0.11 in 21.15. As the training was conducted at the same time, we can conclude that C was more under the influence of circadian rhythm than the training stress. Results like this are familiar in recent literature.

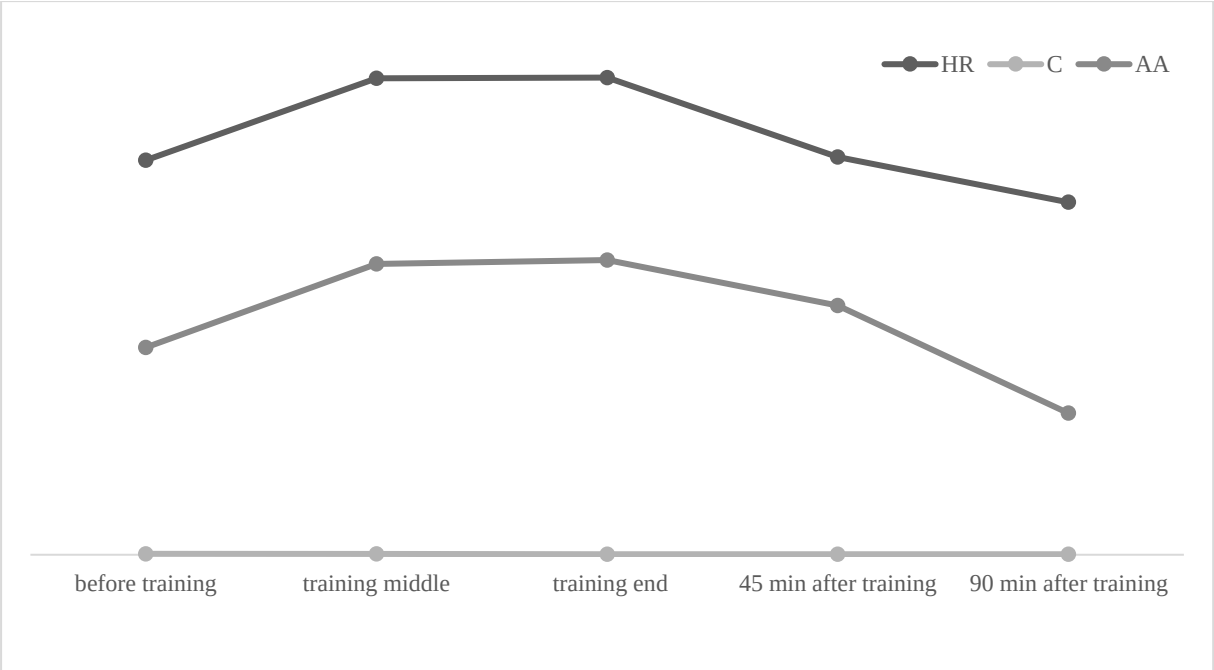
Table 2. Differences between time points calculated with t-test for independent samples

HR differences	p	C differences	p	AA differences	p
HR 1 vs. HR 2	0.01*	**C 1 vs. C 2**	0.05*	**AA 1 vs. AA 2**	0.07
HR 1 vs. HR 3	0.00*	**C 1 vs. C 3**	0.00*	**AA 1 vs. AA 3**	0.03*
HR 1 vs. HR 4	0.79	**C 1 vs. C 4**	0.02*	**AA 1 vs. AA 4**	0.15
HR 1 vs. HR 5	0.01*	**C 1 vs. C 5**	0.06	**AA 1 vs. AA 5**	0.02*
HR 2 vs. HR 3	0.97	**C 2 vs. C 3**	0.02*	**AA 2 vs. AA 3**	0.93
HR 2 vs. HR 4	0.01*	**C 2 vs. C 4**	0.23	**AA 2 vs. AA 4**	0.32
HR 2 vs. HR 5	0.00*	**C 2 vs. C 5**	0.22	**AA 2 vs. AA 5**	0.00*
HR 3 vs. HR 4	0.00*	**C 3 vs. C 4**	0.37	**AA 3 vs. AA 4**	0.17
HR 3 vs. HR 5	0.00*	**C 3 vs. C 5**	0.81	**AA 3 vs. AA 5**	0.00*
HR 4 vs. HR 5	0.00*	**C 4 vs. C 5**	0.51	**AA 4 vs. AA 5**	0.00*

Legend: HR-heart rate. **C**-cortisol. **AA**-alpha amylase. **1**-before training. **2**-in the middle of the training. **3**-imedietly after the training. **4**-45 minutes after the training. **5**-90 minutes after the training, *-statistically significant difference

In the study of Venkataraman et al. (2007) authors concluded that C secretion shows a diurnal rhythm with the highest concentrations in the early morning upon awakening and decreasing concentrations over the day (Venkataraman et al., 2007). It can be stated that in our study, C is not a relevant indicator of the coach's psychological stress during the training or the level of psychological stress is not strong enough to provoke C secretion. Confirmations of the last opinions are the relatively low scores on STAI. That also describes general stress during a training session as not strong enough. On the other side, coaches could be well adapted to training stress and used stress management training. This type of training and adaptation may prove useful in preventing detrimental effects of stress-induced neuroendocrine activation and this way postpone C secretion (Gaab et al., 2003).

Figure 1. Coach stress marker dynamics before. during and after the handball training



Alpha-amylase (AA) show a non-significant increase from beginning till the middle of the training but a significant increase at the end of the training session.

AA dynamics curve presented in figure 1. has almost the same trend as the HR. However, AA levels before, during and after the training sessions were almost 2 times bigger than in the baseline measurement at the same hours. Although AA should exhibit a stable circadian pattern that mirrors that of salivary C, it was not the case in our study (Rohleder et al., 2004). In our study, baseline values of AA gradually increased and stayed on that level from 16,00 till 19,45 hours. On the other hand, C started decrement in secretion in 16,00 hours. According to Rohleder et al. (2004), as salivary alpha-amylase may serve as an easy-to-use index for sympathoadrenal medullary system activity, it is more likely that AA was the most sensitive indicator of the coach's psychological stress during the training sessions.

Conclusion

Current coaching is a stressful job and information about this area can help coaches to cope with this issue. Handball is a team sport game in which its dynamics, huge number of players, a huge number of social interactions, media, expectations and pressure of positive result and achievement could cause important stress load on the coach. It is a presumption that major of these stresses happen during the handball match. Anyway, knowing that almost 90 percent of the coach's job is done on training, we've researched 5 training sessions. Results show that handball training similarly influenced AA and HR dynamics – raising throughout the training and decreasing after. Cortisol levels significantly decreased throughout and after the training which was contacted with: a) low level of training physical stress, b) low scores on STAI and, c) C circadian rhythm. Alpha-amylase shows to be the most sensitive indicator of a coach's acute psychological stress during a training session. Average results and standard deviations of STAI indicate a similar level of stress during different training sessions and relatively low anxiety level during the training session. This study has one major limitation; it was conducted on only one professional handball coach during one week of training. Future studies should be conducted on a larger number of coaches and

involve also match stress measurements. Nevertheless, data obtained in this study directs towards the stressful character of the handball coach profession and could help handball coaches in developing personal training and match stress coping strategies.

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ANALYSIS OF THE GAMING EFFICIENCY OF A HANDBALL TEAM BASED ON INTEGRAL INDICATORS

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Summary

The analysis of the competitive activity of athletes is an important part of the comprehensive pedagogical control and allows: expand the amount of information about gaming activities of athletes; to identify the causal relationships that affect the result of the match; to develop model characteristics of the effective game of the team and handball players of various roles; to determine the development trends of the handball and the technical and tactical peculiarities of the game of each team; to get data on the strengths and weaknesses of the preparedness of each player in the team; to carry out the correction of the training process of the team, taking into account the analysis of the game efficiency.

Key words: *handball team, gaming efficiency, integral indicators,*

Introduction.

To evaluate the effectiveness of the playing efficiency of handball players, various methods of quantitative and qualitative grade of playing indicators are used. To evaluate the quality of the game of a whole team and each handball player in match, the effectiveness of his actions in attack and defense is most often used. In this case, various criteria and methods of evaluation are used, expressed in different units of measurement. In this case, the coefficient of game efficiency can become an integral indicator of evaluation the quality of handball players' game.

To evaluate the contribution of the playing role to the overall team result, the individual effective and erroneous actions of each of the female handball players analyzed, which made it possible to further calculate the group coefficients of the players' playing efficiency by role.

Methods.

Analysis of the official protocols of the competitions of the Russian woman national team at the 2019 World Championship in Japan, analysis of the video recordings of the matches of the Russian national team, analysis of the verbatim records of the games of handball specialists. The integral coefficient of efficiency was calculated as the difference in the sum of positive and reflective actions in relation to their total number.

Research results.

At the group stage, the women's national team of Russia won 5 matches, taking 1st place in the group with 10 points, scoring 158 goals into the gates of the opposing teams and conceding in their 91. At the group stage, the Russian team showed the best difference between goals scored

and conceded - 67, which characterizes the quality of the game both in attack and defense. At the next stage, 3 victories over the national teams of Spain, Montenegro and Romania allowed the team to reach the semifinals of the World Championship, allowing them to fight for the highest dignity medals. At this stage of the main round, the Russian national team scored 98 goals and conceded 72. The difference between goals scored and conceded was 26, again having the best result in the second subgroup.

In the semifinal match with the Netherlands national team, the Russian national team was defeated with a difference of 1 goal, leaving the possibility of getting into third place. Thus, the national team won 9 out of 10 matches, having suffered only 1 defeat.

In order to understand the reason for the loss of the match with the Netherlands national team, it is necessary to conduct a comparative analysis of the effectiveness of the game of these teams - both during the entire tournament and in the meeting between them.

The analysis of the dynamics of the efficiency factor of the team's game as a whole in 10 games of the World Championship (Fig. 1) makes it possible to single out 2 peaks of its highest efficiency, periods of rise and fall in 3 stages of the tournament - a decrease in the overall team indicator from the 3rd to the 5th game, from 7th to 8th and 9th. In the match against the Netherlands national team, this indicator was the lowest throughout the tournament and amounted to 0.1.

To assess the contribution of playing roles to the overall team result, the individual effective and erroneous actions of each of the team's handball players were analyzed, which made it possible to further calculate the group coefficients of the playing efficiency of the players of the national team by role.

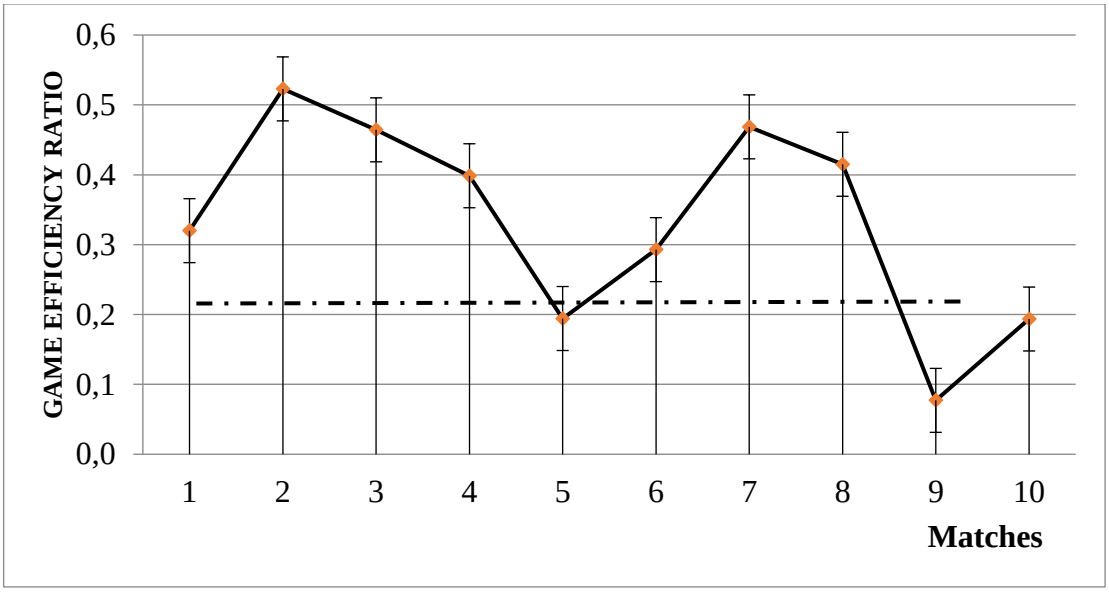

Figure 1 - Dynamics of the efficiency factor of the team's game as a whole in 10 games of the World Championship

The analysis of the dynamics of the playing efficiency of handball players of different roles for the tournament (Fig.2) as a whole showed that, on average, the right-wing players demonstrated the highest quality game (efficiency coefficient - 0.5), point guards took the second place in efficiency (efficiency coefficient - 0.4). All other playing roles in this tournament showed the same effectiveness of the game at the level of 0.3. The obtained indicators allow us to speak about a

fairly stable game of handball players of all playing roles - the coefficient of gaming efficiency is not less than 0.3.

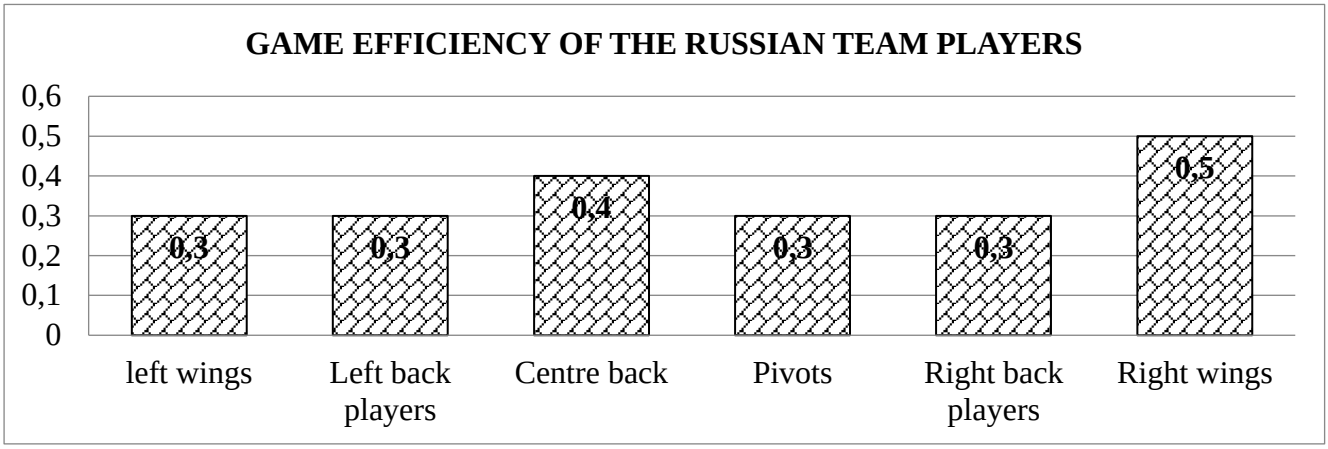

Figure 2 - Game efficiency of the Russian female players by pling position

The World Championship, due to the specifics of the competition formula, is distinguished by a large number of matches for teams that made it to the semifinals; an important characteristic of the quality of the game is the stability of the demonstrated indicators. As can be seen from the data in Table 1, only the right-wing players showed more stable game performance. In doing so, they made a greater contribution to winning the last match in the tournament for the bronze medals. The left wing players in the last two matches showed a negative balance of effective and ineffective actions, the left backs and centre back players made many mistakes in the 6th match with the Romanian national team, and the right backs - in the 5th match with the Swedish national team. The pivots in the last two matches showed a zero balance of the effectiveness of game actions, as well as in the 2nd and 5th games they demonstrated the lowest absolute indicator of game efficiency.

Table 1 - Dynamics of the indicator of the gaming efficiency of players of different positions

Player positions	The number of the match of the women's national team of Russia on WCh 2019									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Left wings	0,2	0,8	0,4	0,5	0,4	1	0,2	0,4	-0,4	-0,6
Left back players	0,4	0,5	0,1	0,5	0,2	-0,1	0,8	0,2	0,2	0,3
Centre back	0,3	0,5	1	0,2	0,6	-0,8	0,9	1	0	0,2
Pivots	0,5	0,1	0,6	0,3	0,1	0,4	0,4	0,5	0	0
Right back players	0,3	0,6	0,6	0,3	-0,3	0,7	0,2	0,1	0,2	0,4

Right wings	0	1	0,4	0,7	0,7	0	0,5	0,5	0,5	1

Comparison of the overall team coefficient of gaming efficiency of the Russian national team and the winner of the 2019 World Championship, the Netherlands national team allows us to state the following.

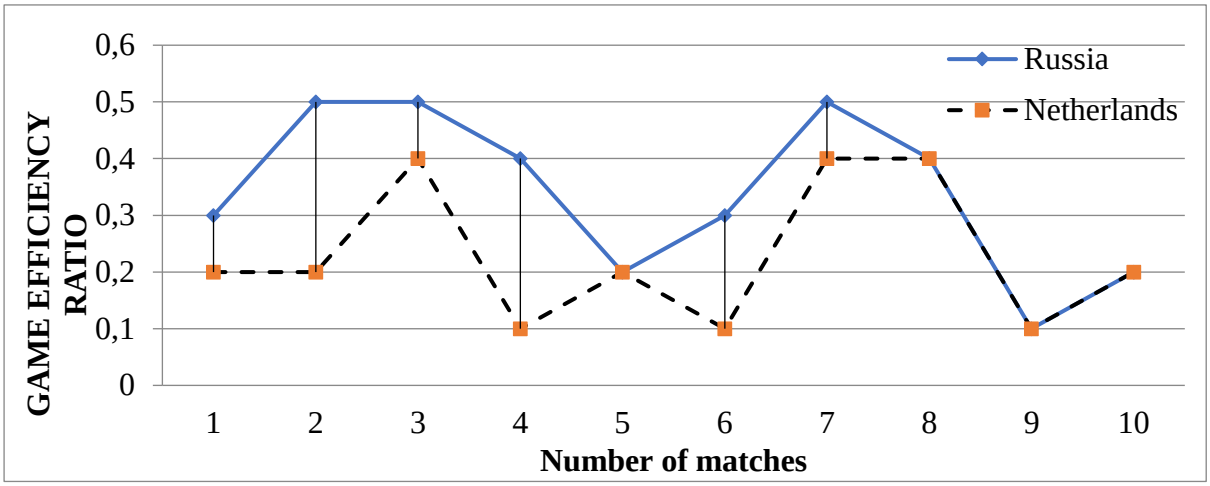

Figure 3 - Comparative dynamics of the integral indicator of teams' gaming efficiency

In general, the nature of the dynamics of the coefficient of gaming efficiency of the two teams has a similar trend, but with a different number of allocated peaks. The Russian national team and the Netherlands national team at the end of the group stage and at the end of the main round had the same overall team coefficient of playing efficiency. Until the 8th match, the Russian national team in 6 matches showed a higher efficiency of game actions.

In the match between the two national teams, both teams showed an equally low overall team coefficient of gaming efficiency - 0.1. At the same time, the effectiveness of attacks by the Netherlands national team (57%) was only 3% higher than that of the Russian national team (54%).

The performance indicators of the game of the goalkeepers of the Russian national team (25%) were 3% higher than those of the Netherlands national team (22%).

Further comparative analysis of the attacking actions of the teams showed that in a fast break attacks, the national team players showed absolutely identical performance indicators.

The coefficient of playing efficiency of players of different roles of two national teams has a similar trend, but with a different number of allocated peaks (Tab. 2).

Table 2 - Gaming efficiency of players different positions in tournament (WCh 2019)

Teams	Number of matchs of 2 teams in tournament									
	1	2	3	4	5	6	7	8	9	10
	Gaming efficiency of left wings									
Russia	0,2	0,8	0,4	0,5	0,4	1	0,2	0,4	-0,4	-0,6
Netherlands	0,7	0,2	0,8	0	-0,2	0	0	0,5	-0,2	0,5
	Gaming efficiency of left back players									
Russia	0,4	0,5	0,1	0,5	0,2	-0,1	0,8	0,2	0,2	0,3

Netherlands	0,4	0	0,5	0	0,4	0,1	0,4	0,6	0,5	-0,1
	Gaming efficiency of centre back players									
Russia	0,25	0,5	1	0,17	0,57	-0,75	0,88	1	0	0,2
Netherlands	-0,5	0,8	0,1	0,6	0,2	0	0,6	0,2	0,1	0,2
	Gaming efficiency of pivots									
Russia	0,5	0,1	0,6	0,3	0,1	0,4	0,4	0,5	0	0
Netherlands	0,1	-0,1	0,5	0,2	0,1	0,2	0	0,1	0	0,2
	Gaming efficiency of right back players									
Russia	0,3	0,6	0,6	0,3	-0,3	0,7	0,2	0,1	0,2	0,4
Netherlands	0	0,2	0,3	0,2	0,2	-0,1	-0,2	0,5	0	0,1
	Gaming efficiency of right wing players									
Russia	0	1	0,4	0,7	0,7	0	0,5	0,5	0,5	1
Netherlands	1	0,3	0,7	0	1	0,3	-0,3	0	0,5	1

Discussion

On the example of analyzing the qualitative indicators of the game of the Russian women's national team at the 2019 World Cup, one can see one example of the analytical work of the coaching team. The data obtained made it possible to identify problem areas in playing positions during a long tournament. Comparative analysis of these integral indicators with the quality of the opposing team's game allows us to draw conclusions about the level of readiness of the team as a whole and individual playing roles of handball players. In this championship, the right back players showed the best stability in tournament.

Conclusions

When assessing the gaming efficiency of each player in a team, it is important to take into account not only the absolute indicators of the quality of play, but also their stability during a tournament or a series of matches. Integral coefficients allow assessing the success of each handball player's game without taking into account the time spent on the playing court. It is known that there are athletes performing exclusively the functions of defenders, or taking free throws, entering the court at the most critical game moments for the team. Therefore, taking into account the ratio of positive (effective) and negative (ineffective) actions of handball players in each match allows us to assess their playing reliability and stability. This, in turn, allows us to formulate objective criteria for the selection of players for the team.

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PORTUGUESE HANDBALL DURING COVID-19 PANDEMIC: IMPACT ON DROPOUT RATES AMONG COACHES, CLUB MANAGERS AND REFEREES

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Summary: In Portuguese handball ecosystem, the organization of training and competitions for youngsters and adults is fundamentally based on associative life and on almost voluntary human resources. One and a half year later the declared Covid-19 pandemic, we returned to a possible normality with those left behind of the prolonged pandemic vacuum. The aim of this study is to analyse the dropout rates among handball coaches, club managers and referees during pandemic.

Keywords: covid-19, handball, coaches, club managers, referees

Introduction

In March 2020, the World Health Organization (WHO) declared the Covid-19 global pandemic and the world stopped their everyday life to comply with the stay-at-home order and thus try to help prevent the spread of the disease. Unfortunately the entire sports ecosystem stopped as well. All over the world, players, coaches, club managers and referees couldn't work in their "normal" conditions.

The analysis of Covid's true impact on sport has drawn a lot of ink and many authors have written on the subject (e.g., Biese *et al.*, 2021; Elliott *et al.*, 2021; Grix *et al*, 2021).

Last summer (2021, last 10th june), on a EHF Club / Federation Management Seminar about handball and the Covid-19 pandemic, Stefan Walzel identify four kind of impacts on sport: impacts on sport and physical activity, impacts on sport clubs, impacts on sport sponsorship, and impacts of sport on sustainability, trying to show the extent and limits of the impacts of the pandemic in the sports subsector.

The great amplitude of these impacts and the transversal nature of the possible approaches give us the idea of a health crisis with priority over everything else.

Considering that, in Portuguese handball, regional federations and local sports clubs play an important role in organizing and carrying out training and competitions for youngsters and adults, the entire structure, fundamentally based on associative life and on almost voluntary human resources, received this impact in a particularly brutal way.

Following the guidelines and prescriptions issued by the General-Directorate of Health *(Direção-Geral da Saúde – DGS*) of Portugal (14/2020, 30/2020 and 36/2020), to the entire sports sector was asked to make an adjustment effort and the proper resilience to sustain the mitigation of covid-19. Among the clarifications published by the Health and Performance Unit of the Portuguese Handball Federation *(Federação de Andebol de Portugal – FAP)*, on September, 8th 2020, we could read: "Competitions are not allowed", "Non-contact training is allowed, with a distance of

3 meters between athletes" and "The sharing of the ball between athletes is allowed" and a dozen more hygiene rules to be followed.

And when everyone tried to savor the new concessions, again, six months later, Portugal had another lockdown and only after that young handball players were finally able to play handball with no restrictions (only without spectators in the stands).

All the sports agents made their share of effort to maintain the motivation to adjust, inform, reorganize, carry out... Finally, one and a half year later, we returned to a possible normality – the "new normal", with the human resources left by the prolonged pandemic vacuum.

The objective of this study is to analyse the dropout rates among handball coaches, club managers and referees during pandemic.

Methods

In our study we use the database of registered sporting agents of the Portuguese Handball Federation (FAP) for a descriptive and interpretive analysis. To obtain the dropout rates of handball coaches, club managers and referees, we compared the records for the sporting seasons of 2018/2019 (before pandemic), 2019/2020 (during the pandemic with a mandatory confinement period) and 2020/2021 (comprising a second mandatory confinement period). Sports agent role, type of handball game, and geographic regions are considered.

Results and Discussion

Dropout Rates among Handball Coaches

As shown in Table 1, the global disruption in Handball Coaches is 22.92%, that is, 290 fewer Coaches in 2020/21. In the same lapse of time, from 2018/19 to 2020/21, the loss of Coaches in Handball of 7 was 18.64% (minus 195) and 46.26% in Beach Handball (minus 99) (in percentage and absolute values).

Table 1

Handball Coaches registered in Portuguese Handball Federation Before and During Pandemic

	2018/2019	2019/2020	2020/2021	Comparison of 2020/21 with 2018/19	
				n	%
Standard indoor handball	1046	1087	851	(-)195	(-)18.64
Wheelchair handball	5	8	9	(+)4	(+)80.00
Beach handball	214	13	115	(-)99	(-)46.26
Total	1265	1108	975	(-)290	(-)22.92

To read this data, we have to report to those of the players. With the dropout rates of players (32.11%), the number of teams decreased and, with them, the need for coaches also decreased. On

the other hand, some coaches lost their jobs during the pandemic and the change in employment, or job schedules, prevented them from continuing as handball coaches.

The year 2019-2020 was catastrophic, in particular, for Beach Handball, with practically all registrations and competition at zero. With the cancellation of the competition, clubs were unable to register any sports agent in this aspect. For the reasons explained above, only with the data from the reopening, we will be able to analyse the loss.

In turn, Wheelchair Handball grew 80% in coaches (plus 4), from 5 to 9. There was an increase in the number of wheelchair handball clubs, 8 to 11, so there was a need for more coaches.

As shown in Table 2, in geographical terms, Azores and Madeira Islands increased the number of coaches, mainly the Azores Islands (two thirds more coaches). The issue of autonomous regions in the management of the COVID-19 pandemic may explain it: these autonomous islands were not required to comply with DGS standards and health guidelines. Because they didn't stop as long as on the mainland, the numbers of sports agents they had registered in recent years (before the pandemic) were not as affected.

Table 2

Handball Coaches registered in Portuguese Handball Federation by Geographic Regions

	2018/2019	2020/2021	Comparison of 2020/21 with 2018/19	
			n	%
North	577	450	(-)127	(-)22.01
Centro	281	219	(-)62	(-)22.06
South	115	97	(-)18	(-)15.65
Azores Islands	15	25	(+)10	(+)66.67
Madeira Island	58	60	(+)2	(+)3.45
FAP (Portuguese HF)	0	0		
Total	1046	851	(-)195	(-)18.64

Note: The data included in this table refer only to the standard indoor handball: the Handball of 7. The mentioned geographic regions are the following: the North Region includes Aveiro, Braga, Bragança, Guarda, Porto, Viana do Castelo, Vila Real, and Viseu; The Centro or Central Region includes Castelo Branco, Leiria, Lisboa, Santarém, and Portalegre; the South includes Algarve, Beja, Évora, Setúbal; Azores Islands includes Faial, Graciosa, Santa Maria, S. Miguel, and Terceira Island; and still Madeira Island and FAP (Portuguese Handball Federation).

Northern and central Portugal lost about 22% of their Coaches. As we have stated before, reading and understanding these data may require an exploratory approach to the reality of the employment / unemployment of the handball coaches themselves, which prevented them to continuing as such.

Particularizing, the inner central region (Castelo Branco and Portalegre) lost 50% of its handball coaches (minus 11). The inner centre has higher dropout rates as they do not have regional competitions and are very dependent on interregional competitions. These were the regional federations that were practically without competition during the entire confinement and even during the restrictions period.

Dropout Rates among Club Managers

Table 3

Club Managers registered in Portuguese Handball Federation Before and During Pandemic

	2018/2019	2019/2020	2020/2021	Comparison of 2020/21 with 2018/19	
				n	%
Standard indoor handball	2629	2555	1698	(-)931	(-)35.41
Wheelchair handball	17	10	17	0	0.00
Beach handball	155	13	128	(-)27	(-)17.42
Total	2801	2578	1843	(-)958	(-)34.20

With regard to club managers, the overall fall is 34.2%, that is, minus 958 club managers. Almost all handball club managers are volunteers. Many of them are linked to clubs/teams as they have their sons and daughters as practitioners. With the stop of activities and then with the resumption, with lower numbers, there seems to be a relationship between the loss of practitioners and the loss of club managers.

In the Wheelchair Handball, and despite the break in the first year of the COVID-19 pandemic (2019/20), in 2020/21 the same number of club managers was recovered as in 2018/19 (i.e., 17). Handball4all teams are mostly APDs, that is, they have their legal framework in Associations for People with Disabilities. The managers of these teams are linked to the APDs long before they had handball in a wheelchair. They are a different type of club manager, which may explain that there was no great instability in terms of dropout rate.

Table 4

Club Managers registered in Portuguese Handball Federation by Geographic Regions

	2018/2019	2020/2021	Comparison of 2020/21 with 2018/19	
			n	%
North	1437	897	(-)540	(-)37.58
Centro	655	404	(-)251	(-)38.32
South	261	155	(-)106	(-)40.61
Azores Islands	42	29	(-)13	(-)30.95
Madeira Island	76	63	(-)13	(-)17.11
FAP (Portuguese HF)	158	150	(-)8	(-)5.06
Total	2629	1698	(-)931	(-)35.41

Note: The data included in this table refer only to the standard indoor handball: the Handball of 7. The mentioned geographic regions are the following: the North Region includes Aveiro, Braga, Bragança, Guarda, Porto, Viana do Castelo, Vila Real, and Viseu; The Centro or Central Region includes Castelo Branco, Leiria, Lisboa, Santarém, and Portalegre; the South includes Algarve,

Beja, Évora, Setúbal; Azores Islands includes Faial, Graciosa, Santa Maria, S. Miguel, and Terceira Island; and still Madeira Island and FAP (Portuguese Handball Federation).

In geographical terms, the North, Centre, South and Azores lose between 30 to 40% of their sports agents. These numbers are very similar to the players, with the exception of the Azores. One of the explanations could be what was stated in the previous point, i.e., almost all handball managers are volunteers and many of them are linked to clubs/teams just because they have their students as players.

Guarda lost all his club managers (100%; 18), São Miguel island, in the Azores (84.6%; minus 11), and Portalegre (83.3%, minus 20) also show significant losses. The regions less developed in handball (such is the case of those mentioned above) have very rudimentary clubs / teams / projects, some of which are still at an early stage. Club managers, therefore, are still in a phase of awareness and not in a stable affiliation.

Leiria loses 55.8% (minus 29) of its managers related to Beach Handball, constituting the most significant loss of this summer modality.

Beach Handball, along with Wheelchair Handball, was 100% stopped during the pandemic. Most clubs did not even register as a form of savings. The loss of club managers may be related to this situation. It is interesting to see whether, with the resumption of beach handball in the summer of 2021, the effect was reversed.

Dropout Rates among Handball Referees

The overall break is 39.8%, that is, 192 referees. With no competitions for months, from *Manitas* to Under-18/19, including some adults groups, the need for refereeing decreased dramatically. There were referees who did not referee a game for over a year. It should be remembered that the resumption of developmental age groups was carried out for many months without similar authorization for arbitration.

Table 5

Handball Referees registered in Portuguese Handball Federation Before and During Pandemic

	2018/2019	2019/2020	2020/2021	Comparison of 2020/21 with 2018/19	
				n	%
Standard indoor handball	482	487	290	(-)192	(-)39.83
Wheelchair handball	0	0	0	0	
Beach handball	0	0	0	0	
Total	482	487	290	(-)192	(-)39.83

The absence of Beach Handball and Wheelchair Handball competitions during the pandemic also reduced the chances of referees to referee, which was another reason for their lack of motivation and demobilization.

Table 6

Handball Referees registered in Portuguese Handball Federation by Geographic Regions

	2018/2019	2020/2021	Comparison of 2020/21 with 2018/19	
			n	%
North	220	131	(-)89	(-)40.45
Centro	109	87	(-)22	(-)20.18
South	85	37	(-)48	(-)56.47
Azores Islands	37	23	(-)14	(-)37.84
Madeira Island	31	12	(-)19	(-)61.29
Total	482	290	(-)192	(-)39.83

Note: The data included in this table refer only to the standard indoor handball: the Handball of 7. The mentioned geographic regions are the following: the North Region includes Aveiro, Braga, Guarda, Porto, Viana do Castelo, Vila Real, and Viseu; The Centro or Central Region includes Castelo Branco, Coimbra, Leiria, Lisboa, Santarém, and Portalegre; the South includes Algarve, Beja, and Setúbal; Azores Islands includes Faial, Santa Maria, S. Miguel, and Terceira Island; and still Madeira Island.

In geographic terms, Madeira Island and the South are the regions that lost the most in referees, with 61.2% (minus 19) and 56.5% (minus 48), respectively. These are the regions where the participation of adult teams in national competitions is low or non-existent, so the probability of the referees having been more than a year without refereeing was enormous.

If we consider only the Inner Center (Castelo Branco and Portalegre), they lost 77.3% of their referees (less 17 out of 22, in 2018/19). The Algarve loses 69.4% (down 34). In these territories, there is no adult team in the 1st division, so the competition was residual or non-existent, so the referees had no regional possibilities to referee without moving by appointment.

If it weren't Terceira Island, which grew by 1100% (from 1 to 12 referees), the Azores Islands brutally loose referees in Faial (93.3%, less 14 out of 15) and in São Miguel (75%, minus 9 out of 12). The Azores have only one team in the 1st division - Faial. On the other islands, like the center and south of the country, there were no regional competitions for over a year.

Finally, Coimbra has referees but does not organize competitive competitions. These take part in regional competitions in Aveiro that did not take place.

In all regions, referees do not live off refereeing. In regional competitions, they arbitrate practically for pleasure and not for financial compensation, which is almost residual. The absence of competition may have led many of them to look for other occupations. On the other hand, several were fired because of the economic crisis and had to find jobs that were not compatible with refereeing (shift work, jobs (night and weekend jobs).

Conclusions

The findings suggest to the entire sporting ecosystem that there is a crisis to be managed. Rainbow banners and the message of hope “Everything will be alright” encourage and inspire us all, but stopping the wave of sports agents’ exodus and regaining the Handball we once had is not easy.

As in any crisis, the challenge of responding, recovering and thriving from pandemic is left in the hands of the agents who remain in the sports subsector.

Here are some practical “crisis management” next steps and questions:

1. Prevent and follow closely eventual conflicts in the sports environment;
2. Prevent conflict of interests between competitive sport and family or free time;
3. Rebuild and strengthen relationships between and with all the people who make up your team / club;
4. Rebuild and strengthen relationships with external partners (sports agents, journalists, sponsors, and vendors);
5. How do you invite sporting agents back, but with added safety precautions?
6. How do you manage the risk to your sporting agents?
7. Get ready to potentially play without or with few fans for a while;
8. Consider the role of social platforms: how might you enhance one-on-one digital engagement between team and fans?
9. Use this crisis to evolve: seize the crisis as an opportunity and consider multiple approaches in this new world.

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PORTUGUESE HANDBALL DURING COVID-19 PANDEMIC: IMPACT ON DROPOUT RATES AMONG PLAYERS

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Summary: The COVID-19 pandemic had and still has a huge impact all around the world. Unfortunately the sports ecosystem was one of the fields more affected. The objective of this study is to analyse the dropout of handball players in Portugal during pandemic. For this purpose we use the database of registered players of the Portuguese Handball Federation, for a descriptive and interpretive analysis.

Keywords: covid-19, pandemic, handball, dropout, handball players

Introduction

Despite the various systematic reviews that show the multiple psychological and social health benefits associated with sports practice for children, adolescents and adults (e.g. Eime, Young, Charity, & Payne, 2013) it is unusual see them walking away from sport, particularly in the teenage years. By declaring COVID-19 a global pandemic and providing a global risk-communication outreach, WHO and national health authorities have given them new compelling and justified reasons for doing so.

The COVID-19 pandemic had and still has a huge impact all around the world. Unfortunately the sports ecosystem was one of the fields more affected. The analysis of Covid's true impact on sport has drawn a lot of ink and many authors have written on the subject (e.g., Biese *et al.*, 2021; Elliott *et al.*, 2021; Grix *et al*, 2021).

Old memories woke up. It was the first time since World War II that organized sport has a lockdown and players have been unable to compete internationally (Pedersen et al., 2020).

In all events, meetings and competitions, elite and grassroots sports were closed and athletes prevented from playing their favourite sports. Portugal and Portuguese handball were not left out of these constraints and stops.

If, after a very short break, the performance athletes were able to return to normality as possible, despite various restrictions (e.g.: not allowed audience), the youngsters were unable to do so and stopped practicing during the first six months. After that, in September 2020, they were finally allowed to return and practice, but without contact, that is, without playing as a team.

Following the guidelines issued by the General-Directorate of Health *(Direção-Geral da Saúde – DGS)* of Portugal (14/2020, 30/2020 and 36/2020), and among the clarifications published by the Health and Performance Unit of the Portuguese Handball Federation *(Federação de Andebol de Portugal – FAP)*, on September, 8th 2020, we could read: "Competitions are not allowed", "Non-

contact training is allowed, with a distance of 3 meters between athletes" and "The sharing of the ball between athletes is allowed."

Again, six months later, Portugal had another lockdown and only after that young handball players were finally able to play handball with no restrictions (only without spectators in the stands).

The only cases of dropouts due to Covid-19 that received the most visibility were participants in a global sport mega-event scheduled for 2020: the Tokyo 2020 Summer Olympics. It was world news headline that, after postponing their Olympic dreams for more than a year after the original start date (IOC, 2020), at least 22 athletes were forced to give up on the Olympic Games, hopelessly frustrating their dreams when they tested positive for the virus, among them the Portuguese surfer Frederico Morais (Fagan, Close, & Martin, 2021). In handball, Portugal had obtained the qualification for is first participation and the entire nation anxiously waited to see the 5th place in Group B of our main national team.

The objective of this study is to analyse the dropout of handball players during the COVID-19 pandemic.

Methods

In our study we use the database of registered players of the Portuguese Handball Federation for a descriptive and interpretive analysis. To measure the dropout of handball players, we compared the records for the sporting seasons of 2018/2019 (before pandemic), 2019/2020 (during the pandemic with a mandatory confinement period) and 2020/2021 (comprising a second mandatory confinement period). Age groups, gender and geographic regions are considered.

Results and Discussion

As shown in Table 1, in the 2018/2019 season (pre-Covid-19) there were 19586 registered handball players. In the last season (2020/2021) only 13297 were registered.

Table 1

Handball Players Registered in Portuguese Handball Federation Before and During Pandemic

	2018/2019	2019/2020	2020/2021	Comparison of 2020/21 with 2018/19	
				n	%
Standard indoor handball	17652	16648	12123	(-)5529	(-)31.32
Wheelchair handball	63	67	87	(+)24	(+)38.10
Beach handball	1871	56	1087	(-)784	(-)41.90
Total	19586	16771	13297	(-)6289	(-)32.11

Data indicate that, during the pandemic and till the last season, around a third of the players have been lost in two years: minus 11.19% in the first year and minus 32.11% last season, i.e., 6289 athletes. At the beginning of the season 2021/2022, coming out of the pandemic, data are very similar to 2020/2021, so it is necessary to understand, at the end of the present season, if the numbers grow, stabilized or maintain the downward trend.

There was no Beach Handball Activity in the season 2019/2020 (Summer 2020) because of the pandemic restrictions. This explains the very low number of registered players.

Comparing Registered Handball Players by Geographic Regions

As shown in Table 2, the North Region had a decrease of 33.20% (-3082 players). The Center Region had a loss of 35.05% (-1522). In particular, the Central Coast Region had a loss of 32.06% (-1287) while the Inner Center (Castelo Branco and Portalegre) lost 71.65% (-235). The South Region had a loss of 27.34% (-590). The Azores Islands lost 2.87% (-13) and the Madeira Island lost 21.56% (-232). The players without club (but registered in the Federations) had a loss of 26.47% (-90).

Table 2

Handball Players Registered in Portuguese Handball Federation by Geographic Regions

	2018/2019	2020/2021	Comparison of 2020/21 with 2018/19	
			n	%
North	9283	6201	(-)3082	(-)33.20
Centro	4342	2820	(-)1522	(-)35.05
South	2158	1568	(-)590	(-)27.34
Azores Islands	453	440	(-)13	(-)2.87
Madeira Island	1076	844	(-)232	(-)21.56
FAP (Portuguese HF)	340	250	(-)90	(-)26.47
Total	17652	12123	(-)5529	(-)31.32

Note: The data included in this table refer only to the standard indoor handball. The mentioned geographic regions are the following: the North Region includes Aveiro, Braga, Bragança, Guarda, Porto, Viana do Castelo, Vila Real, and Viseu; The Centro or Central Region includes Castelo Branco, Leiria, Lisboa, Santarém, and Portalegre; the South includes Algarve, Beja, Évora, Setúbal; Azores Islands includes Faial, Graciosa, Santa Maria, S. Miguel, and Terceira Island; and still Madeira and FAP (Portuguese Handball Federation).
Beach and Wheelchair Handball are very asymmetrically distributed in the country. Beach Handball is practiced only in Aveiro, Leiria, Lisbon, Setúbal and Santarém; and Wheelchair Handball in Algarve, Aveiro, Leiria, Porto and Setúbal.

The data seem to indicate that practitioners' losses had higher incidence in the North and the middle of the country and lower in the South and Islands (Madeira and Azores). However, in global terms,

the data are close for all regions except the Azores. Probably the number of players being quite low in the Azores may have influenced the result.

Comparing Registered Handball Players by Gender

More male athletes were lost (from 2018/19 to 2020/21) (in absolute values and percentages).

Table 3

Handball Players Registered in Portuguese Handball Federation by Gender

	2018/2019	2020/2021	Comparison of 2020/21 with 2018/19	
			n	%
Female	6366	4628	(-)1738	(-)27.30
Male	13220	8669	(-)4551	(-)34.43
Total	19586	13297	(-)6289	(-)32.11

There must be a variable of resilience of the female gender or the limited offer of sports for women here that could explain this difference. Data to be further developed in subsequent studies.

Comparing Registered Handball Players by Age Groups

In terms of age group, 1494 *Bambis* were lost (78%).

At the youngest level, the long break, plus a resumption with many restrictions, could be the explanation for this very large loss of players.

Table 4

Handball Players Registered in Portuguese Handball Federation by Age Groups

	2018/2019	2020/2021	Comparison of 2020/21 with 2018/19	
			n	%
Bambis *(f & m)**	1910	416	(-)1494	(-)78.22
Manitas *(f & m)*		178		
Minis *(f & m)*	2508	1053	(-)1455 **	(-)50.92
Sub12 & Sub13 *(f & m)*	3161	1689	(-)1472	(-)46.57
Sub14 & Sub15 *(f & m)*	3790	2248	(-)1542	(-)40.69

Sub16 & Sub17 *(f & m)*	2858	2595	(-)263	(-)9.20
Sub18 & Sub19 *(f & m)*	1667	1619	(-)48	(-)2.88
Seniores *(f & m)*	3010	3298	(+)288	(+)9.57
Veteranos *(f & m)*	682	201	(-)481	(-)70.53
Total	19586	13297	(-)6289	(-)32.11

Note:

* *f & m* means female and male together.

** Comparing "Minis" (2018/19) with "Minis+Manitas" (2020/21).

In 2018/19 there were no *Manitas*. If we combine them with the *Minis*, it's a drop out of 50.9% (1455 fewer players). The previous point (*Bambis*) and this one have a similar explanation: they are the lowest age groups of handball initiation. We are talking between 4 and 10 years old. They were the last allowed to restart practice but with many restrictions. In social terms, it was the most protected generation and, often, because it was dependent on older generations (grandparents) that they were more protected of the spread of the virus. It seems to us that these may be some of the reasons for such a big dropout.

The dropout is reduced as the group ages grow.

In the intermediate age groups there is another maturity. It was possible to keep the players in activity via videoconference, through individualized plans and other methodologies. When the lockdown had lower restriction measures, physical activity in the outdoor was allowed, reasons that may have helped to mitigate the loss.

Under-18, Under-19 and Adults are the levels where the number of players increased.

The possibility of young players to play in the upper age groups (the only ones who were allowed to have practice and competition with no restrictions – only spectators on the stands was not allowed) gave the opportunity for this players to barely stop during the pandemic.

Also during the lockdown, the player with greater maturity continued to practice, even though videoconference or autonomously. These are the players, between the youth ages, that have greater future ambitions and because of this they probably knew the consequences of a long break.

Masters have a loss of 70.53% (less 481 athletes)

This age group of players, because of their age and some health issues, were at higher risk of contracting Covid-19. On the other hand, most continue to play handball as a physical activity, so the lock down may have provided these players with other alternatives in terms of physical activity.

Conclusions

There is rarely a single reason why athletes fail to train and compete and it is the complexity of the dropout frameworks that makes it so difficult to deal with. Thinking of the Covid-19 pandemic situation as the cause of these abandonment is simplistic and even more incautious is the version that "everything will be all right" when the pandemic declaration is withdrawn.

Stopping the tide of the exodus of athletes is not easy. The findings suggest to the entire sports ecosystem that there is a crisis to manage.

Here are some practical “crisis management” next steps and questions:

- What will it take to find a new normal? Consider multiple approaches in this new world, potentially starting with special and innovative events (reinvented “FESTANDES”) or local / regional tournaments;

- How do you invite players back but with added safety precautions?

- How do you manage the risk to your players?

- Follow closely and rebuild players' relationships, between players and between them and other sports agents, within the team and in the club;

- Gamming and E-Sports have a significant rate of growth during the pandemic: what can we retain from this information?

- Consider the role of social platforms: how might you enhance one-on-one digital engagement between players, or fans and teams?

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CORRELATION BETWEEN BODY FAT PERCENTAGE, BODY MASS INDEX, SPECIFIC FIELD TESTS AND THROWING BALL VELOCITY IN PROFESSIONAL TEAM HANDBALL PLAYERS

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Summary

This study examined the physical fitness, anthropometry, and throwing ball velocity of normal weight and overweight male team handball players. The results of this study indicate that %BF seems to be important for predicting sprint and agility performance. Major attention should be paid to multifactorial parameters to further expand the investigation of intra- and interrelationships between physiological and anthropometric characteristics, including %BF and the performance of handball players.

Keywords: physical performance; handball players; anthropometrics; body fat; body mass index

Introduction

Team handball is a contact sport with brief epochs of high-intensity movements, placing demands on anaerobic and aerobic metabolism, and change of direction [1-3]. Body composition parameters and physical fitness are fundamental to succeed in handball [1,2]. During matches, rapid changes of direction (COD) actions are consid-ered among the activities most frequently performed [4]. Past handball, studies have reported anthropometric characteristics, body composition, and maximal strength, muscle power, and throwing ball velocity constitute the determining factors for com-petitive success in professional team handball [1-7]. Few studies have compared physical characteristics and anthropometric charac-teristics in team handball players of different levels and/or different playing positions [1-4]. Throwing ball velocity is a fundamental skill and handball coaches and scientists concur the main determinants of throwing ball velocity are technique, timing of movement in consecutive body segments, and strength and power of both the upper and lower limbs [7,8]. Concerning anthropometric characteristics, team handball play-ers have been characterized by values of body mass, height, body fat percentage (%BF) and body mass index (BMI) [2,9]. Recent studies suggested anthropometric measure-ments may be related to physical fitness components in team sports [1-7]. For example, high body mass and %BF measurements were related to poor muscle power in soccer [10], basketball [11], and handball [9,12,13] players.

It seems that increased %BF presents different implications for running and jumping performances among athletes and this must be considered by coaches and trainers. Furthermore, there is a need to clarify associations between factors such as %BF and fitness affecting performance in team handball. Therefore, the aims of this study were a) to describe and compare the anthropometric and physical performance stratifying based on BMI and b) to evaluate the association between BMI and %BF with physical fitness and ball throwing velocity. We hypothesized that anthropometry, sprinting, muscle power, jumping, and aerobic performance would be different between normal weight and overweight team handball players. In addition, we hypothesized that %BF would be negatively associated with performance in sprinting, jump-ing, ball throwing velocity, and running tests, even after accounting for other basic anthropometric measures like body height and mass.

Material and Methods

Subjects

Procedures were approved by the national university institutional review board (Approval Number: QU-IRB 1303-EA/20) for human subjects and complied with requirements of the Declaration of Helsinki. Participants provided written informed consent after receiving a verbal and a written explanation of the experimental design and its potential risks. Two groups were devised based upon BMI age-adjusted groups charac-teristics (normal weight; 18.5-25.0: age: 25.6 ± 5.8 years, body mass: 88.4 ± 6.2 kg, height: 1.91 ± 0.06 m, body fat 18.0 ± 3.4%; overweight; 25.1-29.9: age: 25.3 ± 6.4 years, body mass: 97.8 ± 14.4 kg, height: 1.84 ± 0.13 m, body fat 20.6 ± 5.4%).

Testing Schedule

Anthropometry

Body mass (model TBF 105; Tanita Corporation of America, Inc, Arlington Heights, IL, USA) and height (Holtain stadiometer, Crosswell, Crymych, Pembroke-shire, United Kingdom, accuracy of 1 mm) and were measured to the nearest 0.1 kg and 0.1 cm, respectively. BMI was calculated as the ratio between body mass in kg and height in m squared. %BF was assessed with Harpenden calipers (Baty International, Burgess Hill, Sussex, United Kingdom) to the nearest 0.1 mm. Duplicate readings were taken at each site, and the average was recorded. If the two readings differed by more than 2 mm, a third was taken, and the closest two were averaged. The sum of the four skinfold measurements (biceps, triceps, subscapular, and suprailiac) was used to esti-mate of body fat according to the sex- and age- specific Durnin-Womersley equation [20].

Sprint Tests

The sprint times were measured by single-beam electronic photocells (Race-time 2 SF, Microgate, Bolzano, Italy) mounted to the floor and walls. The starting photocell was placed 20 cm above the ground, while the 5-, 10- and 15 m photocells were placed 100 cm above the ground.

Squat (SJ) and Counter Movement Jump (CMJ) Tests

Participants followed a general warm-up preceding 2 min of jumping exercises. SJ and CMJ heights were assessed using Optojump photoelectronic cells (Optojump Next, Microgate, Italy) [21]. Jump heights were measured from contact and flight time of with an accuracy of 1/1000 s (1 kHz). The best of four jumps was recorded for each test, and a 30 s recovery interspersed each trial.

The Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1)

The Yo-Yo IR1 was conducted as described by Krustrup et al. [24]. The relia-bility of the test has been established with a coefficient of variation of 3.6% and an in-traclass correlation (ICC) coefficient of 0.94 [24]. The test was terminated if participants failed twice to reach the front line in time (objective criterion) and/or felt unable to complete another shuttle at the required speed (subjective criterion). The total distance covered was considered as the test score.

Medicine Ball Overhead Throw

Medicine ball throws were performed using a 3 kg rubber medicine ball with a diameter of 21.5 cm (Tigar, Pirot, Serbia). Subjects began with a familiarization session. A brief description of the optimal technique was given, suggesting a release angle to achieve a maximum dis-tance of throw [23]. Criteria for an acceptable test were recording of the better of two definitive trials. The distance was recorded to the nearest 1 cm.

T-half test for change-of-direction (COD) ability

A 10-min warm-up including jogging, lateral displacements, dynamic stretching, and jumping preceded the T-half test for change-of-direction (COD) ability [22], where-after data were recorded using electronic timing sensors (photocells, Kit Racetime 2 SF, Microgate, Bolzano, Italy

Throwing Ball velocity

Explosive strength was evaluated on an indoor handball court, using a 3-step running throw and a jump throw. [25]. The throw with the greatest average velocity was selected for further analysis

Statistical Analyses

All variables are expressed as means, standard deviations (SDs), minimum and maximum values (range), and 95% confidence intervals (95% CI). Mean differences between normal weight and overweight were tested using one-factor univariate general linear model [26]. Differences between means were considered statistically significant if p-values were less than 0.05 and partial eta-squared values were higher than 0.15 [27]. In order to evaluate the influence of body fat and the additional explained variance, in the second step %BF was included in the regression analysis as third predictor. R^2 and the change of r^2 between step 1 and 2 and the non-standardized regression coefficient ß for all predictors and steps were reported. The magnitude of Pearson product-moment-correlations (r) between measures was interpreted according to the following guidelines: if r was <0.1, the correlation was deemed trivial; in the range 0.1-0.3, it was judged small; in the range 0.3-05, moderate; in the range 0.5-0.7, large; in the range 0.7-0.9, very large; and in the range 0.9-1.0, almost perfect [28]. Therefore, $r^2>0.5$ (explained variance>50%) was defined as

meaningful and marked in bold. Regarding the sample size of n = 25, the critical value for the prod-uct-moment-correlation, based on a two-sided t-test [29].

Results

BMI based comparisons

Based on the category of BMI norm (cut off: 25.0 kg/m²), 56% (14/25) of the subjects were overweight. The BMI varied from 22.4 to 41.9 kg/m². Three handball players (12%) showed a BMI above 30 kg/m². The body fat values ranged from 13.3% to 30.1% and only one athlete showed a body fat above 30%. Only for the bicep skinfold were significant differences observed ($p=0.027$, $\eta_p^2=0.196$). Of course, the distinguishing criterion BMI was significantly different between both groups (24.1 ± 0.84 vs. 29.0 ± 4.57 kg/m²; $\eta_p^2=0.339$).

Table 2. Participants' physical characteristics by category of BMI norm (normal weight vs. overweight) and comparison of parameters between both groups based on the first testing set. Data are presented as means ± standard deviation. Significant differences ($p<0.05$ and $\eta_p^2>0.15$) are marked in bold. SJ = squat jump; CMJ = countermovement jump; Yo-Yo IR1 = Yo-Yo Intermittent Recovery Test 1.

	normal weight (n = 11)	**overweight** (n = 14)	**total** (n = 25)	**ANOVA** p	**ANOVA** η_p^2
Age (years)	25.6 ± 5.82	25.3 ± 6.41	25.5 ± 6.04	0.918	0.000
Anthropometric parameters					
Body height (m)	1.91 ± 0.06	1.84 ± 0.13	1.87 ± 0.11	0.098	0.114
Body mass (kg)	88.4 ± 6.15	97.8 ± 14.4	93.6 ± 12.3	0.056	0.150
BMI (kg/m^2)	24.1 ± 0.84	29.0 ± 4.57	26.8 ± 4.19	**0.002**	**0.339**
Body fat (%)	18.0 ± 3.35	20.6 ± 5.39	19.5 ± 4.70	0.180	0.077
Bicipital skinfold (mm)	5.00 ± 1.90	9.25 ± 5.68	7.38 ± 4.86	**0.027**	**0.196**
Tricipital skinfold (mm)	11.4 ± 3.59	13.4 ± 6.81	12.5 ± 5.62	0.380	0.034
Subscapular (mm)	15.5 ± 6.61	18.4 ± 10.0	17.1 ± 8.65	0.410	0.030
Suprailiac (mm)	13.0 ± 6.31	18.2 ± 8.12	15.9 ± 7.69	0.096	0.116
Performance parameters					
15 m sprint (s)	2.51 ± 0.44	2.48 ± 0.46	2.49 ± 0.44	0.874	0.001
30 m sprint (s)	4.38 ± 0.38	4.49 ± 0.43	4.44 ± 0.40	0.489	0.021
Agility T-half (s)	6.28 ± 0.47	6.22 ± 0.47	6.25 ± 0.46	0.772	0.004
CMJ (cm)	48.8 ± 4.72	43.3 ± 5.64	45.7 ± 5.86	**0.016**	**0.227**
SJ (cm)	40.8 ± 6.90	38.2 ± 6.60	39.3 ± 6.71	0.361	0.036
Yo-Yo IR1 distance (m)	1284 ± 210	1211 ± 400	1243 ± 326	0.594	0.013
Medicine ball over-head throw (m)	9.81 ± 1.20	9.63 ± 1.96	9.71 ± 1.84	0.791	0.003
Jump shot (m/s)	29.8 ± 4.30	26.4 ± 4.83	27.9 ± 4.82	0.083	0.125
Running shot (m/s)	33.0 ± 2.09	30.1 ± 5.34	31.4 ± 4.41	0.101	0.113

Only for CMJ was a significant mean difference was detected ($p=0.016$, $\eta_p^2=0.227$). The smallest difference was calculated for the 15 m sprint ($\eta_p^2=0.001$) and medicine ball throw ($\eta_p^2=0.003$). For

15 m sprint (2.51 ± 0.44 vs. 2.48 ± 0.46 s) and agility t-half test (6.28 ± 0.47 vs. 6.22 ± 0.47 s), the performance level in the overweight group was slightly higher than in the normal weight group.

Relationships between anthropometric and physical performance parameters

Before the two-step-linear regression analysis, the collinearity of anthropometric data (body height, body weight, body fat) was checked using by bivariate Pearson's product moment correlation (r) calculation:

- Body weight / body height: r=0.320,
- Body weight / body fat: r=0.343,
- Body height / body fat: r=-0.317.

Regarding BMI, markedly higher relationships were found (body height: r=-0.521, body weight: r=0.633, %BF: r=0.578). The two-step-linear regression analysis with the predictors body height and body weight (step 1) and %BF (step 2) displayed an increase of explained variance by adding %BF in the second step. The r^2 changes between the first and second step ranged from 0.04 (CMJ, SJ) and 0.53 (Agility-T-half test).

Relationships between anthropometric and throwing ball velocity

Normal weight and overweight handball players did not show significantly differences regarding throwing performance parameters. The largest difference was detected for jump shot (p=0.083, η_p^2=0.125). Normal weight subjects showed a higher throwing velocity (29.8 ± 4.30 m/s) than overweight athletes (26.4 ± 4.83 m/s). All throwing parameters displayed the strongest relationship to body height, body mass and body fat (step 2; Table 3). In sum, these anthropometric parameters showed the highest predictive potential for running shot (r^2=0.65), jump shot (r^2=0.61), and medicine ball throw (r^2=0.57). The additional benefit of adding the parameter %BF was smallest for running shot (r^2 change: 0.13).

Discussion

The aim of this study was to examine anthropometry, physical fitness, and ball throwing velocity in normal weight and overweight male team handball players. In addition, we examined how %BF explained variations in fundamental field measures of physical fitness and ball throwing velocity. The main findings of this study were that except for %BF, anthropometric parameters were different between BMI groups. Past studies have shown large anthropometric dimensions were advantageous in handball [1-4]. A limited number of studies have assessed the anthropometric characteristics of adult male handball players [1-7]. However, comparisons are difficult because of different ages, playing positions, competition levels and test procedures utilized. For height and body mass, handball players appear to be between volleyball players and soccer and field hockey players [9,17]. Pertinently, the incidence of overweightness in our study was unexpected given the average BMI of elite adult handball players. Consequently, BMIs observed in our participants should not be attributed to sport-specific physiological adaptations.

Similar results were observed for performance parameters. Only for CMJ a significant mean difference was detected (η_p^2=0.227). The smallest differences were calculated for sprint 15 m (η_p^2=0.001) and medicine ball throw (η_p^2=0.003). For sprint 15 m and agility t-half test, the performance level in the overweight group was slightly higher than in the normal weight group. These results may be useful for coaches and trainers, as they were based on tests that reflect the specific characteristics of individual handball playing positions. The findings of the current study may assist in identifying performance capabilities and player development based professional player's anthropometric measurements and fitness records.

Anthropometrics and aerobic capacity

Overweightness impacted jumping performance to a large extent (p=0.016, η_p^2=0.227; normal weight vs. overweight). Stepwise regressions exploring the contribution of %BF to test performances shed light on the specific role of %BF after adjusting for body height and mass. Body height and body mass alone (step 1) were only relevant for throwing parameters, especially for running shot (r^2_{max}=0.52), and the aerobic capacity. Together with %BF (step 2), we calculated the largest r^2 for running shot (0.65), jump shot (0.61), medicine ball throw (0.57 and agility t-half test (0.54). The agility t-half test was also the test with the largest increase of r^2 (0.53). Even though results are in line with the literature, it was necessary to consider the broader impact of %BF, as a continuous variable, on performance characteristics. This result is in line with previously published studies indicating that having more %BF is associated with lower aerobic fitness in children and adolescents [37,38]. This correlation has been relatively well explored in the general youth population [37,39]. In addition, other findings also indicated that the negative correlation between %BF and VO_{2max} was not significant in 25 female athletes of 17–22 years old [40]. In adult male soccer players and youth basketball players, a negative effect of fatness was found on selected parameters of physical fitness, including both anaerobic and aerobic components [10,11].

Anthropometrics and aerobic capacity

Normally, elite and professional team handball players have greater aerobic capacity than other divisional players, possibly resultant from greater overall weekly training volume [1,2]. As such, the ability to perform high-intensity intermittent exercise for match duration, and to recover from high intensity exercise bouts should be considered a logical criterion in team-handball selection, training, and testing [1,2]. Based on the results of the presented study, it seems that the combination of body height and body mass is a sufficient predictor for medicine ball throw (r^2=0.29), Yo-Yo IR 1 distance (r^2=0.29), jump shot (r^2=0.30) and running shot (r^2=0.52). The additional benefit by adding step 2 was greatest for the agility T-half test (r^2 change: 0.53). The lowest predictive power for all anthropometric parameters was observed for SJ (r^2 step 1: 0.05, step 2: 0.09). The largest additional explained variance was calculated for Agility-T-half test (0.53), 15 m sprint (0.38) and jump shot (0.31). A decreased %BF lead to a higher performance in almost all parameters (exception: sprinting and agility parameters). For example, a reduction of 1% body fat induced an increase of jump shot velocity by 0.69 m/s, an extension of the Yo-Yo IR1 distance by 32 m and improved medicine ball throw by 23 cm.

Conclusions

Professional team handball players from the Qatar handball first league presented a %BF of 19.5 ± 4.7, which is considered relatively high for athletic populations. Team handball players with increased %BF showed lower performance in fundamental physical fitness tests. BMI measurements are unable to differentiate between fat and lean masses, and therefore can be considered a poor indicator in predicting components of physical performance in handball.

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ANTICIP8 – DESIGN AND EVALUATION OF A COGNITIVE MOTOR TEST TO ASSESS ANTICIPATION AND DECISION MAKING IN TEAM HANDBALL

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Summary

Perceptual-cognitive skills in sports were often assessed with the usage of the temporal occlusion paradigm, often without motor contributions within test setups. We designed a temporal occlusion test with multi-dimensional motor response characteristics, and assessed intra- and inter-session item reliability. Significant Cohen's (0.44–0.54) and Fleiss' (0.33–0.51) kappa statistics revealed moderate agreement of motor responses, indicating reliable psychometric properties of a complex, near-game test setup for assessing anticipation and decision making in team-handball.

Keywords: temporal occlusion; decision making; anticipation; decision time

Introduction

In team sports, players use relevant visual cues of their opponents to score or prevent goals, or simply to position themselves in an advantageous initial situation in attack or defense. Visual information about player positioning (Abernethy et al., 2001; Murphy et al., 2018) or postural cues (North et al., 2016; Runswick et al., 2018; Ward et al., 2002) can be used to anticipate an opponent's intention (Gredin et al., 2019; Helsen & Starkes, 1999; Savelsbergh et al., 2002) and allows for making punctual decisions. To investigate anticipation and decision making in laboratory settings, temporal occlusion (TO) (Jones & Miles, 1978) is a well-established paradigm that has been applied in several studies. In TO, action sequences are occluded at different times in order to restrict the visual information available and thus to create varying stages of anticipatory requirements. TO can therefore be used to identify postural cues that influence predictions of future actions or to distinguish better from worse players (Brenton et al., 2016; Causer et al., 2017; Müller et al., 2006).
Previous studies using this method have demonstrated that high-skill athletes outperform their low-skill counterparts in response quality, meaning that they pick up less visual information to foresee intended movements in action sequences. A systematic review, conducted by Mann et al. (Mann

et al., 2007) found an overall expert-novice between-group difference ($p < .001$) for response accuracy with an effect size of 0.25 in 64 selected TO studies.

When considering that the TO paradigm has been applied in the past 40 years, very limited knowledge about reliability and reproducibility of the paradigm itself exists. Even though expert-level comparisons indicate validity, reliability is an equally important psychometric property with direct relevance for applied and basic research on developmental or training-induced changes in decision making. So far, reliability analyses in TO are mostly based on the prediction outcomes of the participants. In volleyball, a cross-sectional study using a computer test with binary choice options (Loffing, Hagemann, et al., 2015) investigated the internal consistency of prediction responses in a visual anticipation test. A split-half-technique, using the Spearman–Brown formula, revealed a reliability coefficient for video pair responses of .72. Longitudinal studies in racquet sports demonstrated high inter- (r =.92) and intra-rater-(r =.98) reliability for decision accuracy in cricket (Brenton et al., 2019) or for response accuracy in tennis (r =.90-.96) (Williams et al., 2002) and softball (r =.74 and r =.99) (Gabbett et al., 2007). Here, intra-class correlation was used, and accuracy calculations were executed with interval scaled variables. Especially the effect of choice of outcome parameter, test design (cross-sectional or longitudinal) or test setup on later interpretations of the obtained findings remains to be questioned.

Moreover, other works with TO examined mainly accuracy outcomes in the form of dichotomous choice options (e.g. ball flight direction or type of throw). In team-handball, especially the 7 m penalty, a rather isolated closed-game situation, was mostly the central object of investigations. Here, a study by Loffing, Hagemann et al. (2015) revealed differences between experienced and novice goalkeepers in anticipating hard or lobbed shots, and accuracy increasing with later occlusion conditions. Results were confirmed in another study by Cocić et al. (2020). The binary outcomes were obtained in computer-based test settings or as a verbal report, and often without a timely restriction. Such lab-based test setups could surely lead to diminished expert advantages but it seems to only partially capture anticipation skills (Mann et al., 2007). In one of a few studies, Williams et al. (2002) noted more rapid decision times of skilled players in a real-world test scenario in tennis. Here, participants had to respond to real-life tennis serve projections by taking a step to one of four pressure sensitive pads and by swinging the racket as if to intercept the ball. Ratcliff et al. (2016) also emphasized in their work the inclusion of response times measures in multialternative choice assessments.

To sum up, investigations dealing with open-game situations in team sports, in which field players face multialternative attack or defense decisions, are strongly lacking. The general importance of sport-specific anticipation measures with near-game tasks and real-size projections is recommended in the given literature (Dicks et al., 2010).

Methods

Apparatus and stimuli

Sixty-six male team handball players (M = 17.89 years, SD = 7.64 years) from six teams, of different age and performance levels (elite under-15; amateur and elite under-17; elite under-19; amateur and elite adult), participated in this study. Four elite teams (n = 44) belonged to a youth academy of a professional team handball club of the German Handball Federation, competing at the highest league possible within their age category. The elite adult competed in the professional

Third League as an under-23 team. Two amateur teams (n = 22) were recruited from the rural and city area of Magdeburg, Germany, competing at the local level. All participants completed one test session for within-session reliability analyses (session 1). Two teams (*n* = 22) underwent two test sessions for between-session (longitudinal) reliability analyses (session 1 and 2).

To create the test scenario, first of all we recorded four representative attacks of an elite center back player (*Breakthrough, Jump throw, Standing throw, Pass;* Kromer 2015), which later were temporally occluded within a general time frame of the ball being passed to an attacker (t6) and the obvious end of the attack (t0), with time intervals of 200 ms (t6 = −1200 ms; t5 = −1000 ms; t4 = −800 ms; t3 = −600 ms; t2 = −400 ms; t1 = −200 ms; t0 = 0 ms) (see **Fig. 1**). Finally, we doubled every video clip for the envisaged reliability analyses. We created 112 videos, resulting in a total of 224 video clips when dummy trials are also considered (4 base stimuli × 2 dummy trials × 7 TO conditions × 2 doubled × 2 handedness).

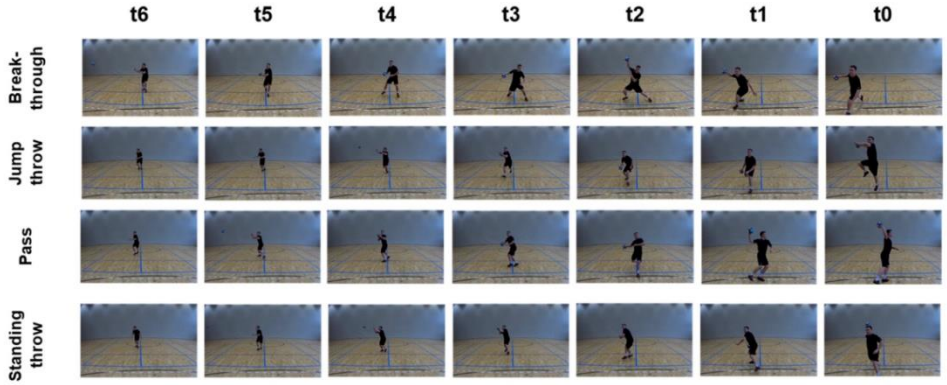

Figure 1. Screenshots of occlusion time points of the 4 right-hand baseline video stimuli.

Four defensive actions (*forward movement/tackling, sideways movements (left/right)* and *passive position/blocking)* were assigned to the SpeedCourt® contact plate system and a life-size projection screen (**Fig. 2**).

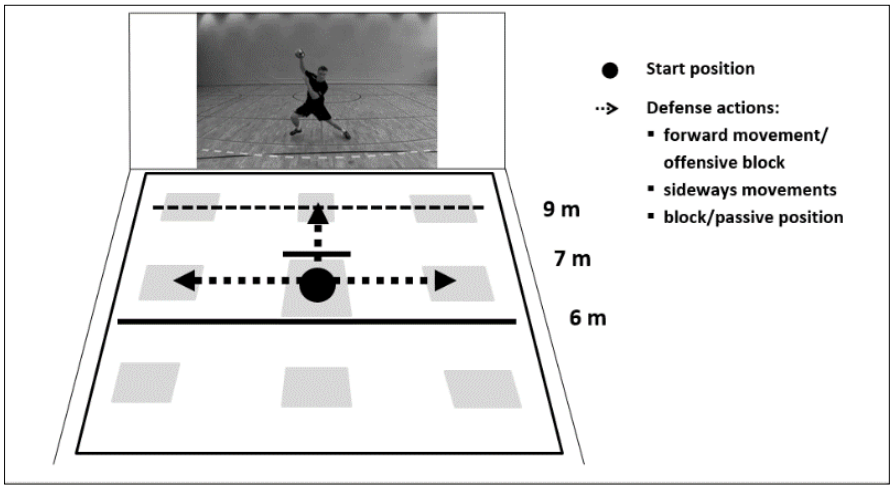

Figure 2. Motor responses as defensive actions with respective contact plates on the SpeedCourt® in front of the projection screen.

Our experimental test setup required participants to motor respond with one of the four defense actions (*forward movement/tackling; sideways left or right movements; passive position/blocking)* on the actions executed by the attacker in the video clips. Participants always started as a center block player in a classic man-to-man defense system, positioned on the 7 m line on the central contact plate (**Fig. 2**). When assuming the starting position, a 3 s countdown appeared on the screen with an attack video following. Participants were instructed to respond as fast as possible after each presentation ended. Throughout the test scenario the video's time lengths increased and so the information content in it as well (one right- and one left-hander video block with randomized video clip orders, starting with t6-videos, ending with t0 videos). We recorded *choice of motor response* (multi-categorical) and *decision time* (as initialized time of motor response, in ms).
Cohen's kappa (Cohen et al., 1960) was used for intra-session reliability of doubled videos for respective agreements of *choice of motor responses* (within-session from session 1). Fleiss' kappa (Fleiss et al., 2013) was used to assess between-session reliability of two x doubled videos for agreement of *choice of motor responses* (sessions 1 and 2). With respect to *decision time*, we were interested in whether the expected pattern of faster initialization times in response to videos containing more information was present. After a KS-test for normality distribution, differences in *decision time* as a function of occlusion time point within test session 1 were assessed with one-way repeated measures ANOVA. The significance level for all analyses was set to the conventional $p < .05$.

Results

Discussion

The aim of the present study was to create and evaluate a real-world like test environment to address cognitive-motor skills in team-handball. Specifically, in line with recommendations in the literature (Löffler et al., 2020; Travassos et al. ,2013; Roca et al., 2011; Dicks et al., 2010; Morris-Binelli and Müller, 2017; van Maarseveen et al., 2018), our test uses a) a life-sized projection screen on a contact plate system, b) varying open-game attack actions from team-handball, and c) multi-categorical motor defense actions. Within- and between-session reliability analyses generally revealed moderate agreements of the motor responses chosen. With increasing visual information about the attackers' unfolding actions, participants more rapidly initiated their defense actions.

With temporal progression in the videos, the attacker offers more information about the intended action through an ongoing occurrence of kinematic cues, what apparently lead to facilitated clarifications about the tactical decisions made by the defending participant. The resulting accuracy increase in later occlusion time points are in line with several computer-based TO studies (Farrow et al., 2005; Loffing, Hagemann, et al., 2015). Regarding the motor aspect in this study, our results are also in good agreement with the findings of Farrow et al. (2005), where accuracy of decision quality from tennis-specific return strokes improved over occluded time points. Through the overall linear decrease of motor initialization times in the occlusion time course, we suppose that motor response times in our TO model are associated with decision making processes

and accuracy outcomes. Projected to the one-on-one situation in team-handball, an earlier perception from an attacker's future motion could lead to higher success rates of the defender's actions realized with embodied choices. Generally, using motor initialization times in complex TO settings could also benefit future accuracy outcomes (e.g. through identification of waiting strategies before decision making (Afonso et al., 2012), or in the context of embodied choices (Raab, 2017).

Reliable measurements constitute a basic prerequisite for reproducible correlational studies, cross-sectional group comparisons, and longitudinal studies (within or between groups) (Hopkins, 2000; Loken & Gelman, 2017). Yet surprisingly, to the best of our knowledge, no study to date systematically investigated the reliability of multi-categorical performance metrics in TO research. Cross-sectional studies revealed some evidence for reliability in the TO paradigm in team-sports. Internal consistency analysis of a computer-based TO test in volleyball, where participants had to distinguish between smash and lob, found acceptable reliability (r =.72) for video pair responses on interval scale level (Loffing, Hagemann, et al., 2015). When novices (no experience in competitive volleyball) and skilled volleyball players were separately analyzed, coefficients decreased to .66 and .55, respectively. With respect to intra-session reliability, we generally found moderate-to-substantial response consistency (right- and left-handed) in all occlusion time points evaluated. Therefore, besides one exception (Pass), reliability estimates reported here were comparable to the Loffing, Hagemann et al. (2015) study.

A closer look at our data revealed attack-specific differences in terms of reliability, which emphasizes the specificity of varying open-game situations. For example, in Breakthrough, the late occluded videos (t3; t2; t1) revealed relatively high levels of agreements. In these occlusions, the full action intention of the attacker seemed to be terminated due to a highly dynamic run-up (t0 till t1) and a deception movement at t_3, which is why most participants just reacted subconsciously in the following occlusions (t4 till t6) with most likely identical decisions. That may explain the visible rise of the level of agreement in Breakthrough. A further example for necessity of varying game-situations is given by the different distinctions of reliability between right- and left-handed Jump throw attacks (inter-session). Higher left-hander reliability in later occlusion points (t4 – t0) could be traced back to a different defense behavior based on greater uncertainty, of how to defend a left-handed player. In fact, left-handed players in team-handball are less frequently represented in team-handball (Loffing, Sölter, et al., 2015), which leads to divergent level of agreements.

Similar to within-session reliability, there are only a few longitudinal studies that report between-session reliability. Without a TO approach, a related study of Raab and Johnson (2007) assessed long-term reliability in the context of option-generating research in team-handball. Over a 2-year measurement period, their experimental setup contained full video clip presentations of competition-like attack situations, with the perspective of an attacker onto the defense line. After the end of each video clip (frozen video frame) participants were instructed to verbally report generated options of the player in possession of the ball. Reliability estimations for decision quality within four measurement points were calculated using the split-half test. Spearman-Brown coefficients for quality of the first option ranged from .49 in test wave one to .89 in test wave two. The variability of response reliability in their analyses can be compared to the distinctions of our inter-session Kappa values, ranging between fair and substantial. Recommendations by the authors about further longitudinal studies in heuristic settings in sports were given as well. Other

investigations with the TO paradigm, executed in cricket, tennis and softball, found overall high reliability (r = .74 – .99) for decision and response accuracy (Brenton et al., 2019; Gabbett et al., 2007; Williams et al., 2002). Probably, the high reproducibility reported in these studies can be explained by the close-game character of test setups (batting in softball and cricket; tennis serve), with accuracy outcomes consisting of binary predictions of ball flight directions of type of throw. In this study, we found response agreements ranging from fair to substantial. A possible explanation for the fact that agreement in our study was slightly worse compared to racquet sports studies is that we used a complex test environment in combination with multi-categorical (instead of binary) response outcomes.

A detailed view on inter-session agreement data reveals that the highest Kappa values occur in the earliest or latest occlusions. This provides margins for interpretative patterns about either easier or more difficult tactical decisions to make at these time points. High Kappa values can be explained by the participants' full knowledge about the attacker's intention in the video clips, especially in the late occlusions at the end of an attack sequence. High Kappa values in the earliest occlusions seem to suggest that too few kinematic cues in the video clips were given for an early and risky defensive intervention by the participant. Few information at the beginning of an attack seem to rather excluded certain response options, such as sideways movements for example, within the decision making process. The exclusion of options increases the response probability for the options that are left, and so the chance to identify the appropriate option at the same time. Based on a more concentrated number of the likelihood of responses, the Kappa agreements increase. The comparably low Kappas later in the ongoing attack (t5 – t3) seem to suggest that the amount of kinematic cues in the attackers' movements reached an oversupplying limit in the participants' decision making, shifting from intuitive to rather deliberative. In particular, we suspect these time points to be crucial for the perceptual-cognitive skills based on anticipatory information pick-up.

Conclusion

In sum, we have extended previous studies by demonstrating that the TO method can be considered as a reliable measurement tool based on cross-sectional and longitudinal investigations in team-handball. We found fair to moderate agreements of multi-categorical defense responses with obvious tendencies to substantial and excellent agreements. We have also illustrated that the combination of the TO paradigm with team-handball specific motor responses on a test battery demonstrate feasibility. The team-handball specific nature of the test battery, including a reliable anticipation test method (TO) in a real-life inspired decision making setting, can contribute not only to improvements in cognitive study designs and interpretations, but also to a deeper understanding of cognitive mechanisms in team-handball. As psychological abilities are claimed to be one of the most momentous performance prerequisites in team-handball (Groeger et al., 2019), our test offers possibilities not only for visuomotor training interventions but also for talent identification and talent development processes in team-handball.

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DEVELOPING A TOOL TO ASSESS HANDBALL PLAYERS' COMPETENCES

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Summary

The aim of this publication is to present the work in progress of an instrument developed to evaluate the essential competences of players in team sports and its pedagogical possibilities in handball. Content validation was performed by specialist to evaluate the instrument's indicators. Content validity coefficient was calculated, and the results show means above the cut-off value (0.80) in all criteria.

Keywords: Handball; Assessment tool; Validation; Essential competences.

Introduction

Handball is one of the most prominent sports in our time. The chain of actions resulting from the conflict of objectives (in attack and in defense) generates a context of a certain unpredictability, requiring those who play it competence to act in accordance with the circumstances of the game (Reverdito & Scaglia, 2007; Galatti et al., 2017; Garganta, 1995). The circumstances of the game are triggered by the relationship of opposition and cooperation between two teams, whose objective is determined by the possession (or not) of the ball, seeking constant success in actions (Lamas et al., 2012; González et al., 2017; Menezes & Kings, 2017). Therefore, it presents itself as an environment in which a broad repertoire of skills is required to the players be able to act efficiently and effectively during the game.

In this context, information about the players' game level, that is, their competence to act in the game, is essential for the coach to be able to organize and plan future steps, which makes the assessment an essential tool. From the assessment and evaluation instruments, it is possible for coaches to collect important information about the level of play and progress of their team (tactical, strategic, and technical), helping them with data to be able to model and guide game and training

sessions (Greco et al., 2015; Tavares, 2017; Costa, 2010). However, a study by Leonardi et al. (2017), points out that the number of instruments available for assessment is still small, considering the need to observe other aspects of the learning process. From this perspective, our aim is to present the work in progress of an instrument developed to evaluate the essential competences of players in team sports and its pedagogical possibilities in handball.

Methods

A mixed method research approach was used to stage the elaboration of indicators in two steps: based on theoretical references and validation of the instrument's content (Thomas et al., 2012). The first step was to study and analyse theoretical references available in the scientific literature regarding the assessment in team sports games (TSG) and essential skills. From this it was possible to appropriate the theoretical framework capable for the development of indicators to assess teaching and learning in TSG. To establish the indicators, proposals for the systematization and organization of team sports based on the idea of competences (Scaglia, 2014; Scaglia et al., 2013; Lima et al., 2017; Reverdito and Scaglia, 2018), and studies that signalize the importance of understanding the TSG as a complex system with different levels of play (Garganta, 1995; Reverdito and Scaglia, 2007) were used. With the indicators formulated, the next step was the content validation process of the indicators, where 5 experts were invited and 3 of which agree to participate (Cassepp-Borges et al., 2009). Based on their assessment, experts pointed out the necessary corrections. The experts were Brazilian researchers with PhDs in Physical Education and Sports linked to public higher education institutions with scientific productions in team sports and evaluation.

Content validation

Content validation is a way to assess the weaknesses and strengths of an instrument (indicators), so it is possible to check its reliability and assess what is proposed. For this content validation, we use the following criteria: clarity of language (CL) - considers the language used, considering the target audience; practical relevance (PP) - considers whether each item is relevant to the instrument; theoretical relevance (RT) - considers the level of association between the item (indicator) and the theory; theoretical dimension (DT) - looks for if the items are adequate with the studied theory. Professionals evaluated each instrument indicator using a Likert scale (Cassepp-Borges et al., 2009; Folle et al., 2014; Hernández-Nieto, 2002).

Data analysis

For content validation, the Likert scale was used to assess each of the indicators in the following criteria: CL, PP, RT and DT. To analyse the data obtained (CL, PP, RT), the content validity coefficient (CVC) was used, which was considered valid when they presented general indices equal to or greater than > 0.8 (Hernández-Nieto, 2002). To assess the DT of the instrument, the response of 2 evaluators was used, which were explored from the Kappa coefficient, according to the criteria of Cassepp-Borges et al. (2009). For statistical analysis Excel 2019 and SPSS 25 software were used.

Results

In the final version of the instrument for the Content Validation Coefficient (CVCc-total) all criteria of the 19 indicators managed to reach satisfactory indexes (Cassepp-Borges et al., 2009; Morales et al., 2012). The CL presented a result of 0.80, the PP 0.90 and the RT 0.89, and, therefore, they are all equal or higher than the cut-off score. For the DT evaluation criterion, the indicators obtained a mean value of 0.45 in the Kappa coefficient, presenting an agreement considered moderate (Cassepp-Borges et al., 2009). With the new format in relation to CL, 52.6% of the indicators reached indexes above 0.80, for PP they were 94.7% and RT were 94.7% of the items in relation to CVCc-final.

There are indicators with values below 0.80 for CVCc-final, for the CL evaluation criteria they correspond to 47.3% of the items that obtained values below 0.80, and of this value 21.05% had indexes between 0.63 and 0.69, and 26.31% reached values of 0.76. For the PP and RT, 5.2% of the indicators presented indexes below, with a score of 0.76 for both criteria. Analysing the instrument, it was decided to keep all current indicators (19), even those with indexes below 0.80 in one of its criteria, since this feature is provided for in the content validation methodology (Cassepp-Borges et al., 2009) and are important for the coherence of the study, as the average (CL+PP+RT/3) of each item exceeds 0.80.

Discussion

We seek to develop an instrument that brings a new perspective to the assessment in team sports. Based on the results of the content validation, we arrived at the final version with 19 indicators, with evaluative criteria above 0.80 for the CVCc-total. For the DT criteria, which showed moderate correlation (Kappa= 0.45), and the CL criterion, the results can be justified by the characteristics that result from the game circumstance (Reverdito & Scaglia, 2007). Competencies do not occur in isolated, but simultaneously (Scaglia et al., 2013). In other words, the circumstance of the game may demand different skills from players. Therefore, it is possible that the indicators in our study (actions performed in the game) can be classified into different theoretical dimensions.

The evaluation criteria that stood out the most were in relation to practical relevance, with a score of 0.90, and theoretical relevance, with a 0.89 of CVCc-final. These results reveal that the developed indicators have the attribution to assess what is intended to, having relevance recognized by the evaluators, also that the items are related and based on the theory of essential competences (Scaglia et al., 2013; Scaglia, 2014; Reverdito & Scaglia, 2018; Lima et al., 2017). Therefore, it shows that the indicators are well grounded in theory, with the ability to assess what is intended (Cassepp-Borges et al., 2009). That said, in Table 1 (next page) we present the indicators in their final format.

Table 1 – Final Indicators

	INDICATORS
Action communication (attack)	- The player does not understand the game, does not know what actions to take during the game's attack and does not understand the game rules. - The player is already able to understand attacking situations, creating passing lines and putting himself in a position to score. - The player observes the game (opponent and teammates) and chooses the best decision (score, keep the ball, progression) for the conclusion of the attack.
Action communication (defence)	- The player doesn't worry about defending and does not understand the rules of the game. - The player tries to defend but struggles to recover the ball. - The player can read the opponent, managing to recover the ball and prevent attacking situations. - The player can analyze the game, choosing the best decision (individual or collective marking, etc.), occupying spaces in support of defense.
Space structure (attack)	- Bundling around the ball when attacking. - The player moves to receive or pass the ball. - Players can intentionally organize themselves on the field to progress to the attack.
Space structure (defense)	- Bundling around the ball in the defensive moment. - The player tries to move to defend and/or retrieve the ball. - The player manages to position itself in space collectively, obtaining spatial and/or numerical advantage to recover the ball and prevent the attack, achieving success in these defensive actions.
Relation with the ball (attack)	- Difficulty handling the ball and/or body movements when in possession of the ball. - Can even minimally handle the ball and thus perform or position to receive passes. - Can be effective in handling the ball, thus managing to perform the best action (finishing, keeping the ball, progression) towards attacking.
Relation with the ball (defense)	- Focuses only on who is in possession of the ball, in the defensive moment of the game. - Perform interception or can effectively prevent some attacks. - Can recover the ball, being effective in recovery.

Source: Authors

The final version presents indicators divided into 3 skills (communication in action, relationship with the ball and space structure), where each of these groups has corresponding items for the different phases of the game (attack and defense phase). This division in relation to the game phases was attributed considering that team sports are constituted by a dynamic and complex context, where moments of cooperation and opposition occur (Reverdito & Scaglia, 2007; Scaglia et al., 2013; Machado et al., 2019). Understanding these characteristics, we attribute to the indicators the idea of operational principles of attack and defense (Bayer, 1994), as the skills required for each game phase differ.

With these indicators, the coach will be able to analyze and evaluate the development of students/athletes, individually and collectively in the handball game environment. In a simple and practical way, the indicators are based on direct observation of essential skills to respond to the circumstances of the game at some level, and, therefore, as a method of procedural assessment (Lamas & Seabra, 2017). Thus, it will be possible to recognize the competences of the players at some level, since everyone is able to play, and able to obtain the adequate feedback for the next teaching and learning objectives.

The instrument did not consider specific skills defined by positions in handball in this validation stage, for example, goalkeeper, pivot, 1st liners and wingers, which could be considered in future research. By understanding these indicators characteristics, it can be considered an assessment tool for the initial stages of handball learning, where training should offer the opportunity to experience various positions within the game (Vieira et al., 2017; Collet et al., 2017), And, fundamentally, assess the repertoire of essential skills for a good level of play. Therefore, the instrument presents itself as a good alternative to help coaches in their evaluative practice.

Conclusions

In the validation of the content of the indicators, satisfactory values were reached, showing that the indicators are well grounded in theory and that they have the capacity to evaluate. Therefore, it can become a tool that can help coaches with information capable of supporting the development of quality handball practice. It is important to highlight that the content validation process shows that the indicators formulated in this study assess what they really intend to assess. However, it is necessary that these indicators still need new assessments and tests (e.g., user field test) to demonstrate their efficiency and reliability during the assessment. Next steps would be to consider specific skills defined by handball positions and instrument content validation to English language to make it available to more coaches. Therefore, this study opens new possibilities for research in the handball assessment, based on essential skills.
We hope that this instrument will allow coaches to observe and assess players' individual and collective developmental process, to support their pedagogical decisions and, to contribute with new pedagogical possibilities to improve coaches' educational programmes.

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MY HANDBALL SYSTEM

DRAWING, STORING AND PRESENTING TRAINING EXERCISES AND GAME IMAGES DIGITALLY

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Zoltán Kólya (My Handball System), Hungary

Summary

My Handball System® is a newly developed complex software which supports handball-related professional activities in a revolutionary new and unique way, providing limitless creativity to its users. The programme offers many quick and simple alternatives for modelling game situations in 2D and 3D by using authentic images, objects, lines and multiple handball court templates. It allows for storage and archiving this information on an external data medium.
Key words: handball, digital planning, 2-3D images, design tool, software, game situations

Introduction

There is a variety of software on the international market which helps the work of handball coaches. At the top of the market, XPS Network for example, is an often-used coaching platform for high profile teams and focuses on the key elements of planning, analysis, and communication. Similarly, Dartfish provides high quality video analysis solution that allows mostly analysts to capture, analyse and share videos of training sessions and matches. Yet these programs do not aid (were not designed for) the everyday work of those coaches working with not so high-profile teams in planning and designing training sessions. The other range of available software better focuses on graphic design. Therefore, we closely analysed and compared them to each other according using the same criteria then drew conclusions *(Table 1).*

	VERSION	PRICE	PAYMENT DUE	LICENC NUMBER	SYSTEM	COMPATIBILITY	DOCUMENTUM MAKER	3D	VIDEO EDITOR	SAVING - CLOUD	LANGUAGE	EXERCISES	SUPPORT
Tactic 3D Handball	Basic	39,99 EUR	M	1	PC/MAC						ENG		
	Team	99 EUR	Y	1	PC/MAC/And.	Lic.					ENG		
	Club	299 EUR	Y	3	PC/MAC/And.	Lic.	x	x	x		ENG		
	Pro	Individual	Y	E	PC/MAC/And.	Ind.	x	x	x	x	ENG	x	x
Sportdraw Handball	Sportoffice + Sportsdraw	78440 HUF	M	1	n.a.	x	x		x	x	30	x	
Sportplan	Free	FREE	-	1	PC				x	x	ENG	x	
	Premium	44,99 EP	Y	1	PC		x		x	x	ENG	x	
	Club	Individual	Y	E	PC/And./iPad	x	x		x		ENG	x	x
	School	99 EP	Y	15	PC/MAC/And.	x	x		x		ENG	x	x
TacticalPad		63 USD	Y	1	MAC/PC/And./iPad	x	x	x	x		ENG	x	
Handball Board Soft	Free	FREE	-	1	MAC/And.				x	x	ENG		
Tactical Board	Free	FREE	-	1	PC				x		7		
Easy Sports-Software	Easy	194 EUR	M	1	PC/MAC		x	x	x		5		
	Club	730 EUR	M	5	PC/MAC	x	x	x	x		5		x
Sportscoachingsystem	Full pack	49 EUR	M	1	PC/ MAC		x	x			ENG		

***Table 1**: Summary - the features of sports drawing and analysing software Tactical 3D Handball, Sportdraw Handball, Sportplan, TacticalPad, Handball Board Soft, Tactical Board, Easy Sports-Software or Sportscoachingsystem*

We found that most of these programs focus on a specific area or the programs which integrate the different areas of handball coaching are not detailed enough and not of high quality. Moreover, they provide little possibility for the users to be creative because most programs work with set templates. Thus, users do not have any real opportunity or possibility for feedback to the designers to indicate their experiences and specific needs. Furthermore, half of these programs use 2D modules only, they don't support cloud services and do not provide a digital library for the users with a pool of exercises.

We have also noticed that Hungarian handball coaches had to work with a multitude of different foreign programs for modelling the training and game situations or in some cases even needed to use other, not handball specific programs/software. Therefore, based upon the needs, a thorough market research and by utilising the best points of the existing programs we have developed this digital drawing, storage and presentation tool for teachers, coaches and trainers working in handball.

My Handball System is a cloud-based program developed in JAVA, so it can be widely run on currently used operating systems (Windows, Android, Mac / iOS). Thanks to this, it also runs on smartphones and tablets, which provides added mobility for users.

Methods

The first steps to mathematically describe the curves were taken by aircraft and car design engineers as early as the early 1940s. There were continuous developments in the 1960s and 1970s about curves that could be described by multi-member algebraic expressions. The initial steps were taken by the aircraft and automotive industry in 3D surface design in the 1960s and the involvement of large computer companies in the development was also key. A turning point in the development of CAD **(**Computer Aided Design) systems was the creation of the SKETCHPAD (the first program ever to utilize a complete graphical user interface) system in 1961 at Massachusetts University of Technology. For the first time, the opportunity arose here for the designer to intervene directly in the graphics system. In this system, this was accomplished using a cathode ray tube (graphics display interface) and a light pencil (the mouse used today). Displaying and modelling Sketchpad objects on the screen has become the foundation of modern graphic computing used in advertising, business, entertainment, architecture, and web design. As computers gradually became cheaper and easier to use, and personal computers appeared, so did the use of CAD in virtually every engineering design.

By utilising the latest discoveries and modern technology, our goal was to support the professional work of handball experts working for federations, clubs, educational institutes and other handball related organisations with a high-quality IT based digital handball drawing and professional, planning software. In order to achieve this, we laid down the *most important principles*, defined the *target group* and specified the *functions* for creating the program.

The principles of creating the program

Credibility and authenticity - Handball professionals were involved in the software development process. They gave input and added value to the users to satisfy their needs, to make them feel comfortable using it.

Tailor made design - Although set templets and figures help the flow of the work, some functions can be customised according to the demands of the individuals.

Ergonomics - The working environment must be comfortable for the users, so optimally placed functions, simple use of equipment and access of areas with minimal interactions are necessary.

Efficiency - In order to save time a very clear interface must be provided, focusing on the most important functions and providing quick access to users.

Aesthetic appearance - Modern graphic design, comfortable user interface and functions needed to present handball as a modern game in a spectacular and appealing way.

Artificial Intelligence - Multiple built-in automations help to prepare trainings/ practices the fastest way possible.

Affordable – Creating a fair price-value ratio, which makes it readily available and accessible to handball professionals and teams with lower budgets.

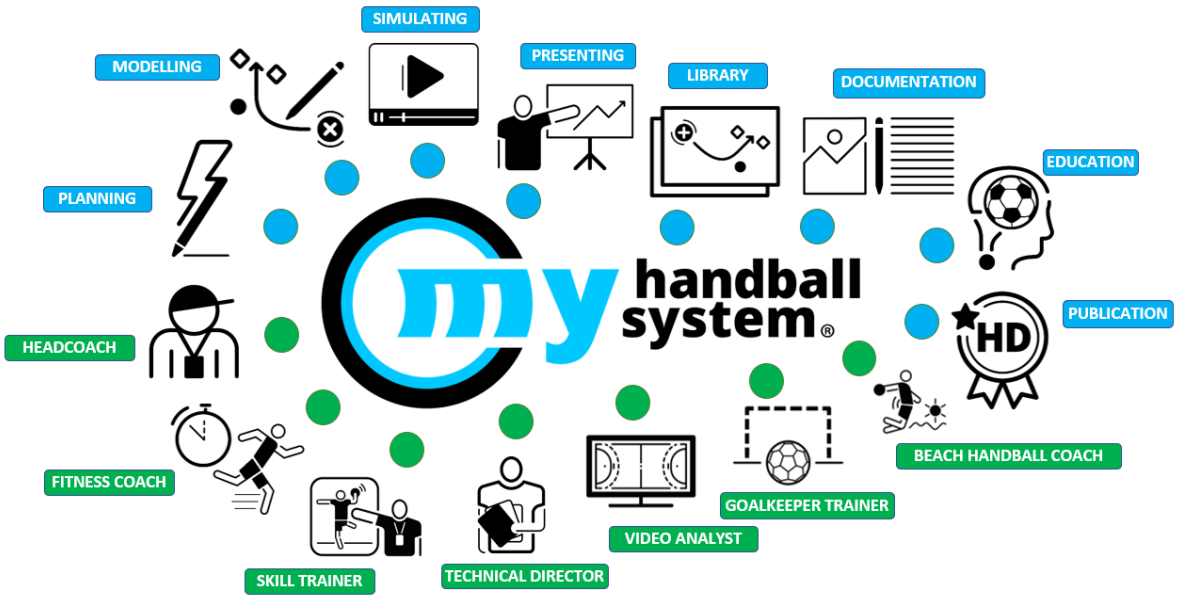

***Table 2**: Specific functions (marked in blue) and target groups (marked in green) of My Handball System*

1. Target groups of the program

The program supports the work of all handball-related professionals, such as:

Coaches (head coach, assistant coach) - Daily training plans can be easily created, by using previously set layouts and exercise templets.

Trainers (goalkeeper trainer, individual skill trainer, fitness trainer) – Allocating group work during training or conducting an individual training for the players, the exercise pattern, particularly in circuit training, can be easily set up.

Analysts (video analyst, performance monitoring) - Interesting playing patterns and tactical moves from footage can be transformed and animated.

Officials (referees, delegates) – Important points of observation can be visualised, and movement paths of referees can be simulated and converted into a digital program.

Leaders (sport director, technical director) – A program leader of the club or federation will be able to create a game philosophy, set up a pool of exercises in different categories and demonstrate them to his/her coaches.

2. Specific functions for the users

Digital planning - The software offers a quick modelling of training and game situations with the help of objects, lines and multiple handball pitch templates.

Simulation -The programme can transform 2-dimensional images prepared with pictograms and lines into 3-dimensional images within seconds. In the 3D view, users can easily examine various situations from different angles and distances.

Documentation editor - It is possible to include relevant written professional content to training and game situations in the side panel. This text will become an integral part of the document which can be saved and re-imported.

Presentation and saving formats - Images and documents can be saved in different formats. Editable format: mssd; Image and image book format: png; document format: pdf; presentation and phase-animation format: html.

Education - The software uses internationally accepted signs and symbols (eg.: the ball or player movements) and the spectacular 2D-3D graphics make the program easy to understand for students.

Publication - The quality of images saved (with a png extension) in FULL HD, so they can be used for publishing and for printed media.

Internet knowledge base - Users can select exercises from 10 themed databases through our website (www.myhandballsystem. com) and import them into the project they are working on.

Following the establishment of these set of goals, our next task was *to create a digital platform* that integrates all areas of professional work of the handball experts *(Image 1).* As for the IT base, we heavily relied on some proven methods from My Soccer System. For the 2D drawing the international symbols from handball literature was adopted and partly modified. While for the perfect 3D appearance we have carefully designed a *stereotype handball player* (man and woman) by digitally putting the muscle groups on a skeleton. Then we checked this player from all angles and selected those *typical body postures* that often appear in the game and demonstrates well the given movement.

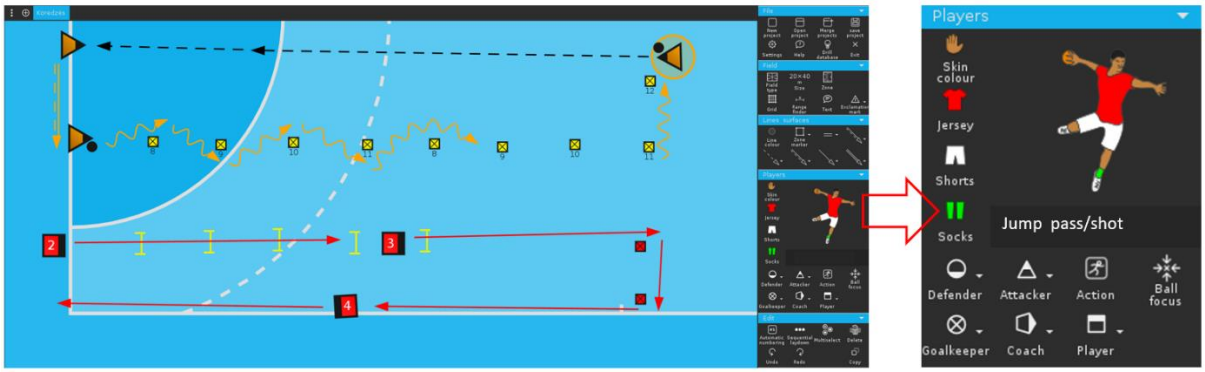

***Image 1**: Opening page of the digital platform, featuring game images of the handball player*

Having established the platform and the tools, the next step was to put all these into action and create handball-like movements. Apart from simple moves like player advancing on the court, marking the path of the ball, we programmed unique yet very practical functions such as *ball-focus* (for a click every player turns towards the ball) *automatic set up* (with every click a player or objectives can be placed on the court without going back to the main menu), *colour chart* (changing the skin and the playing gear of the players individually or as a team), or *exercise progression* (putting the sequence of movement automatically). Apart from these functions the software was already programmed for visually helping the learning process (e.g.: converting 2D drawing into 3D images with a single click, being able to turn the handball court around 360 degrees, setting the height of the players and the path of the ball, attaching name tags or numbers to the players, etc.) Combining the possibilities of the software program with our handball expertise, it has become possible to create spectacular *sequences of exercises* and reproduce images from the real game for reasons of analysis.

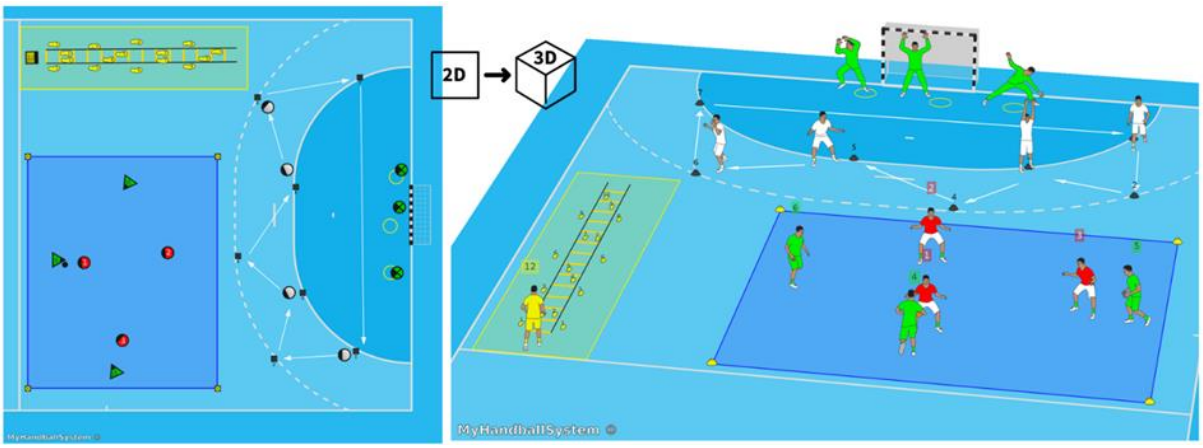

***Image 2**: Converting 2D drawing into 3D images with a single click*

This function leaves room for creativity for sports professionals in a form never seen before, digitizing professional ideas in a simple, fast and spectacular way so images then can be used for different purposes: *textual information* can be assigned to the created plans and they can be saved together and then reloaded at any time; the phases can also be represented in time, as a *sequence of motions* and the end product can be an animation or a story telling sheet. A well-known uniformalised and internationally well accepted *key of symbols* marking system has been

developed focusing on the most important parts of the game: the player, the movement of the ball, the line markings and the playing court. These symbols help coaches *transfer and share information* more easily, dismounting the language barrier between coaches from different countries. The movement patterns of the players, the tools that occur, and the tracks make the final representation even more realistic. Moreover, since players and equipment are scaled proportionally, the coach sees exactly what they are in reality *(Image 2-3).*

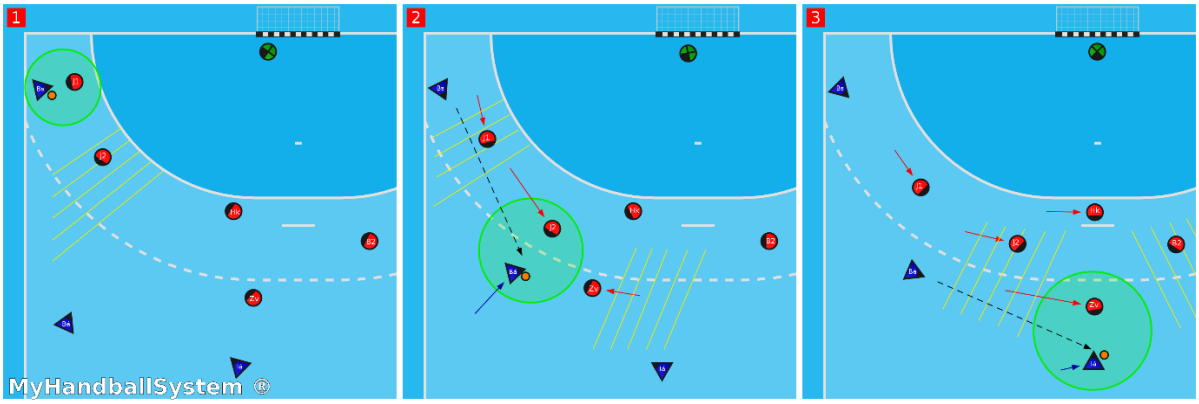

***Image 3**: Automatically creating a pictorial storybook, using pre-made images*

The next task was to find *how to best save* the created images and to file them in such a way, that they can be called upon at ease, extended, presented and used for *different purposes* and at the highest quality possible. So, we programmed the software in such a way that the image created can be used for multiple purposes: it is possible to create *high quality PDF* from the image, convert the drawing directly to a *Power Point Presentation*, number the sequences and thus create a *pictorial storybook*, or an *animated movie* by simply pressing a button. However, high quality visual presentation without information and instructions would not be complete as a teaching and learning aid. Therefore, we designed *a unified templet* where instructions, important points, coaches' hints and key factors can be added next to the training exercise. These complete training exercise sheets can then be tagged with pictorial symbols and saved in a *digital library* with a unified catalogue system *(Image 4).*

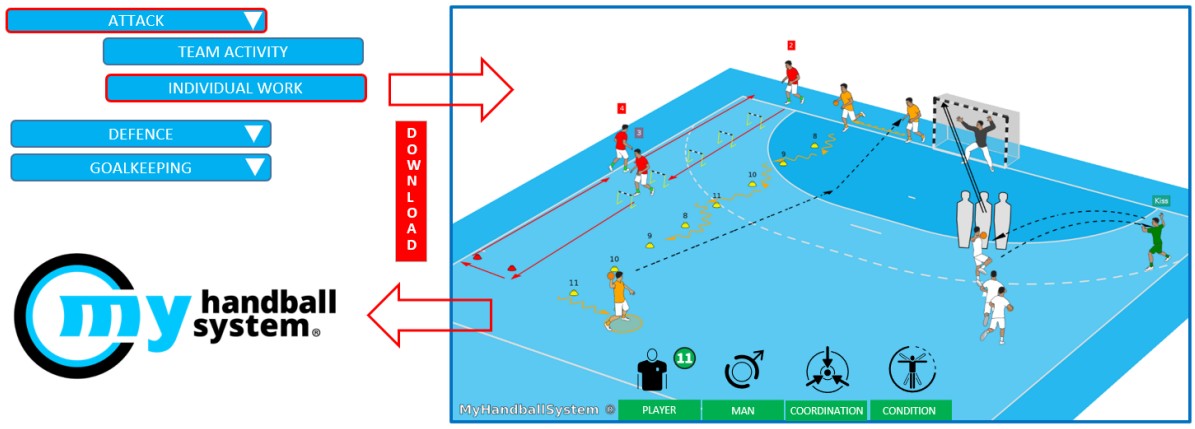

***Image 4**: Tagging exercises and saving them in the digital library with a catalogue system*

Results

After achieving our initial aims and realizing our goals we created a Pilot-version of My Handball System and decided to put it to the test. The annual coaching in-service of the Hungarian Handball Federation provided an excellent opportunity for us to introduce the concept to the coaches and to seek feedback. We included this project in the course program so from May to August 2021 at nine venues, a total of 2410 handball coaches (all the coaches renewed their licence for the 2021/22 season) were made aware of and became familiar with this new digital tool for handball experts. Having collected the feedback from those coaches we have further perfected My Handball System and created an English version for those coaches, teachers, experts who wish to extend their knowledge and facilitate their planning work.

Conclusions

Handball has reached the stage that our spectacular sport deserves a better and high-quality image/presentation at all areas. The coach's knowledge and time can be better utilised and, instead of the traditional and time-consuming way of old, digital software can be used for planning and storing training sessions, as well as for presenting their work at a high quality. The Pilot project was well accepted by the people working in the field of handball and demonstrated that this digital tool has definitely got room in the word of handball. Furthermore, some functions can even be tailored made and customised according to the demands of the coaches. The programme can transform 2-dimensional images prepared with pictograms and lines into 3-dimensional images within seconds. In the 3D view, users can easily examine various situations from different angles and distances. Images and documents can be saved, stored and archived in different, editable formats. These high-quality drawings then can be presented in FULL HD for educational purposes or can be used for publishing and for printed media. We strongly believe that My Handball System with its modern graphic design, user friendly interface and with various functions can be a very useful tool for handball coaches at all levels.

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PHYSICAL TESTING IN ELITE TEAM HANDBALL: SPECIFIC PHYSICAL PERFORMANCE VS. GENERAL PHYSICAL PERFORMANCE

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Summary

Twenty-three female adult top-elite field team handball players from the Danish Premier Female Team Handball League performed a team handball game-based performance test (GBPT) and two standardized general physical tests, the Yo-Yo intermittent recovery test, level 1 (Yo-Yo IR1 test) and a separate linear 30-m single sprint performance test (SSPT). Overall, the results revealed that the GBPT is better than the Yo-Yo IR1 test to evaluate female adult top-elite field team handball players´ ability to perform physical match-related activities including both locomotive and technical playing actions. The present data also suggest that the 30-m SSPT only to a certain extent can measure the individual sprint capacity of elite team handball players. In conclusion, this study clearly indicated that team handball specific physical performance, as measured by the GBPT, and general physical performance, as measured by the Yo-Yo IR1 test and the 30-m SSPT, are different components.

Keywords: Team handball specific physical performance, technical playing actions, oxygen uptake, blood lactate, general physical performance

Introduction

Based on previous scientific studies and knowledge about the practical world of sport, testing of the physical performance in team ball sports seems to have been performed mainly by use of general tests that are almost identical for the various team ball sports. This also applies specific to team handball (Granados et al., 2013; Michalsik et al., 2015a; Hoppe et al., 2017). The results of these general tests have, e.g., been used to determine individual physical performance profiles, to evaluate the effects of various kinds of training, to separate players into various performance groups and to determine if the players were ready to return to play after a period of injury. Furthermore, it has been used in the player selection process of top-level teams. Thus, it is absolutely essential to know if the results from general aerobic, anaerobic or strength tests are specifically related to the on-court performance in team handball match-play.

A previous study showed that a highly advanced game-based performance test (GBPT) for team handball was a valid and reliable test to analyse team handball performance (using both physical, physiological and biomechanical variables) under conditions similar to competition match-play (Wagner et al., 2016). The GBPT was developed according to previous time-motion analysis of elite team handball matches, which has shown that match activities every minute

include numerous high-intensity events (accelerations, decelerations, and change of directions) and also various team handball specific movements like passes, throws, blocks, screenings, jumps, claspings, tackles, and fast breaks (Michalsik et al., 2013, 2014, 2015b,c).

In the team handball GBPT, peak oxygen uptake (VO_2-peak), blood lactate concentration (BLC), heart rate (HR), sprinting time, time of offensive and defensive actions as well as running intensities time (in offence, defence, fast break, and fast retreat), throwing velocity, and jump height were measured (Wagner et al., 2016). The playing intensities during the GBPT were for the same players similar to the intensities during a team handball test game, and identical to the playing intensities found while analysing match performance in Danish elite team handball players (Michalsik et al., 2013, 2014). Furthermore, when comparing the physical and physiological variables, high correlations were found between the GBPT and the team handball test game. Rating of motivation, exertion, and specificity of the GBPT showed that the players were highly motivated to perform their personals best. Moreover, exertion during the test was very high and close to the exertion of a typical team handball game. Thus, the GBPT was proved to be very well-suited to measure team handball performance and closely reflects the physical performance during real team handball match-play.

The well-known Yo-Yo tests were developed for testing the physical - and more specifically - the locomotive performance of athletes while running back and forth on an indoor or outdoor court. There has been special interest in the Yo-Yo intermittent recovery tests (the Yo-Yo IR tests), since they evaluate the athletes' ability to perform prolonged, intermittent and repeated intense exercise and with that, their potential to recover from intensive exercise. In many sports, for example team ball games like team handball, the exercise is namely intermittent, and the physical performance is related to the players' ability to repeatedly perform intense exercise throughout the entire game.

The Yo-Yo IR test may be performed at two different levels with different speed profiles (level 1 and 2). Level 1 (Yo-Yo IR1) starts at lower speed and with the increases in speed being more moderate than for the level 2 test. For a trained person, the Yo-Yo IR1 test is mainly focusing on an individual's ability to repeatedly perform intermittent exercise with a high aerobic component towards the end of the test (Krustrup et al., 2003, 2006). The test also evaluates the individual's ability to recover from intense exercise. The Yo-Yo IR1 test fully stimulates both the aerobic and anaerobic systems for less trained persons and is therefore normally used to test male non-elite athletes, beginners and female athletes. Consequently, in the present study with female elite team handball players the Yo-Yo IR1 test was used.

In team handball, the number of physical confrontations with opponents and the number of technical playing actions like tackles, screenings, jumps and shots are high. Thus, there are great demands for especially upper body explosive muscular strength. Using only locomotion match data seems to underestimate the physical demands of elite team handball match-play (Michalsik et al., 2013, 2014). Consequently, it seems reasonable to believe, that it is decisive in team handball to use a test that is not solely a measure of the locomotive capacity of the players.

Therefore, it is highly relevant and very interesting to examine and compare the results of the advanced and complex GBPT and the more practical Yo-Yo IR test for elite team handball players. The GBPT is closely resembling the physical performance during real team handball match-play (Wagner et al., 2016), which may be due to the fact that it - in contrast to the Yo-Yo

IR test - also contains technical playing actions like tackles, specific movement patterns in offence and defence, multiple changing of directions, and jumping and shooting with a ball.

The 30-m single sprint performance test (SSPT) is also a general test, which is often used to test elite team handball players´ ability to sprint without changes of direction and including a ball. The linear 30-m SSPT was chosen as sprint test in the present study, since it is the most applied sprint test when scientific studies have used general tests to examine the sprint ability of team handball players (Ingebrigtsen et al., 2013; Krüger et al., 2014; Hermassi et al., 2019; Wagner et al., 2019a). In addition, it is easy to standardize. Consequently, it is relevant to compare this version of a sprint test to the other two tests in the present study.

Moreover, it can also be applicable to investigate the potential differences in test results between the above-stated tests in relation to the different field playing positions (wing players, backcourt players and pivots) to establish the sensibility of the tests - the ability to capture small differences in physical performance between individual players in the various test categories. This study was designed to examine possible relationships between the GBPT, the 30-m SSPT and the Yo-Yo IR1 test for elite team handball field players. Gaining knowledge about these aspects may provide insight into the value of more general tests like the 30-m SSPT and especially the Yo-Yo IR test regarding specifically the latter's ability to measure the effects of relevant physical training and to use the results for planning of optimal physical training regimens in elite team handball.

Methods

Subjects

Twenty-three female players (age: 24.6±3.3 years (group means ± SD); body height: 1.75±0.76 m; body mass: 72.4±9.1 kg) volunteered to participate in the present study. They were recruited from three teams of the Danish Premier Female Team Handball League and included ten backcourt players (BP), seven wing players (WP) and six pivots (PV) of whom seventeen were right-handed, and six were left-handed players. Since the activity pattern of goalkeepers obviously differ greatly from those of field players, all the subjects were field players.

All participants were adult top-elite team handball players. During the two preceding seasons, sixteen players were champions in the Danish Premier Female Team Handball League. In addition, sixteen players were playing or have played in the Women´s European Handball Federation Champions League, and twelve players were world-class players and were playing or have played in the European and/or World Championships for their respective national teams, representing multiple nations. All subjects were physically healthy and reported no injuries, infections or cardiopulmonary risk factors during the time of the study.

Study design - testing procedures

The study was carried out during the beginning of the last part of the preparation phase where the players were not involved in any important matches. All testing procedures were performed indoor under thermoneutral conditions in terms of temperature (18-22° C) and humidity (50-70%). Each club were tested separately, but within the same training week to reduce the impact of seasonal variation on physical performance. The tests were performed on two different days. On the first testing day, all players from the same club performed the Yo-Yo IR1 test at the start of a normal training session on their home indoor playing court. On the second testing day, all players

performed a linear 30-m SSPT and the GBPT on an indoor playing court at the University of Copenhagen in Denmark.

The Yo-Yo Intermittent Recovery Test, level 1 (Yo-Yo IR1 test)

All the players completed the Yo-Yo IR1 test, which was performed as previously described (Krustrup et al., 2003). The Yo-Yo IR tests consist of repeated 2 x 20-m shuttle runs back and forth between the starting, turning, and finishing line at a progressively increased speed until exhaustion controlled by audio signals from a compact-disc player. Between each running bout, the players have a 10-s active recovery period, consisting of 2 x 5 m of low intensity exercise (decelerating and walking back to the starting line). When the players are not able to maintain the speed twice, the distance covered at that point is recorded. The total distance covered is considered as the test result in which the last running bout that the players is starting to perform has to be fully included. Thus, the last 2 x 20 m is included in the final test result. The HR was monitored throughout the entire test.

The 30-m Single Sprint Performance Test (30-m SSPT)

In the SSPT, each player performed a maximal, linear 30-m sprint. The players had to repeat the sprint test twice with at least 4 min of recovery between tests. In order to record the time to cover the sprint distance, three light beams/timing gates was placed at 0 m, 15 m and 30 m of the testing distance. The fastest 15-m and 30-m sprint times were considered to be the test results and was used for analysis.

The Team Handball Game-Based Performance Test (Team Handball GBPT)

The players completed the team handball GBPT in accordance to a description by Wagner et al. (2016, 2018). Briefly, all players performed eight heats of team handball specific movements including defence, defence to offence, offence, offence to defence, and active recovery (see Figure 1). Since the GBPT was developed according to previous time-motion analysis of elite team handball matches (Michalsik et al., 2013, 2014, 2015b,c; Michalsik & Aagaard, 2015), the on-court movements varied in the eight heats reflecting that the activity pattern of team handball players is constantly changing throughout a match.

During defensive actions, players had to tackle padded roll mats on the 6-m and 9-m line with both hands, starting at the 6-m line and finishing at the 9-m line. In offence, players had to catch and pass the ball during sprinting between the 9-m line and 12 m, whereas they have to touch the 0.5×0.5-m touching fields on the floor, starting at 12 m and finishing at the 9-m line. In five out of eight heats, players had to finish the offensive actions with a jump shot, throwing as fast as possible to the lower left corner of the goal after maximal take-off from the left foot (for the right-handed players, and vice versa for left-handed players). In heat 3 and 6, the players had to sprint from defence to offence, finishing with a jump shot (fast break), and in heat 4 and 6 sprint from offence to defence (running back/fast retreat).

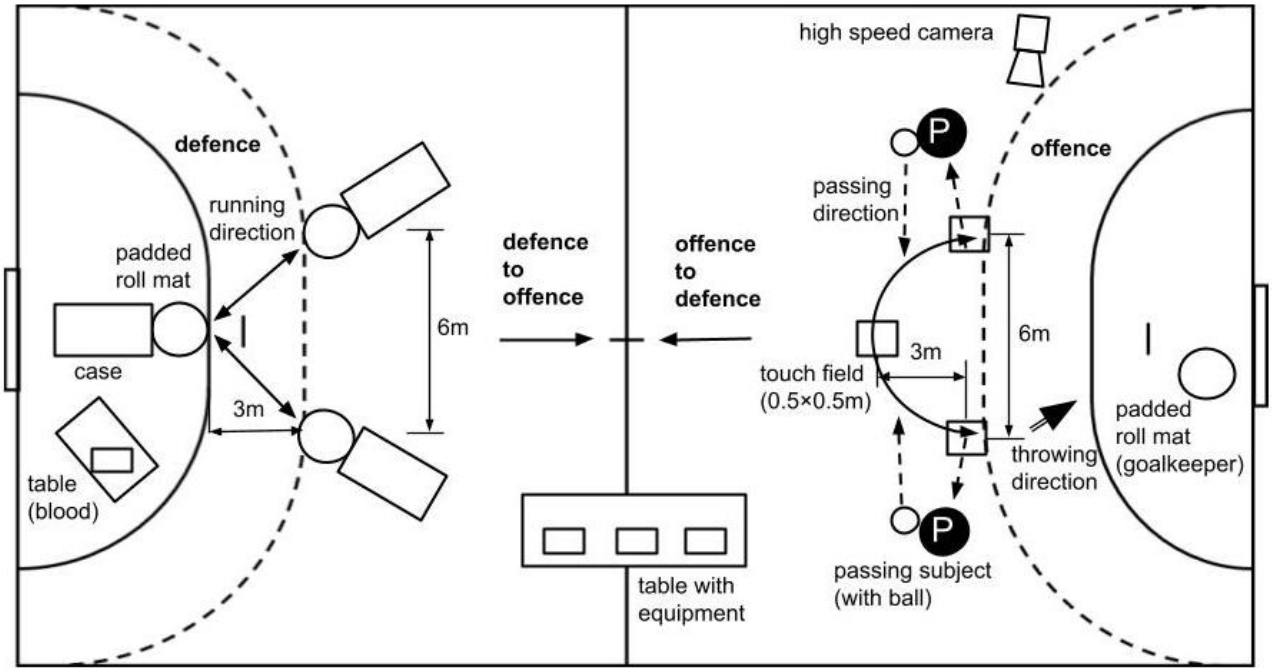

Figure 1. Schematic diagram of the team handball game-based performance test (GBPT) including measuring and testing equipment.

Pauses (15 s between two defensive or offensive actions, 20 s between offence and defence and vice versa, and 40 s for blood lactate measurement) between two heats were precisely controlled. The oxygen uptake and HR were measured in each heat using a portable respiratory gas exchange measurement analysis system in breath-by-breath mode and a HR belt with a sensor module. VO_2-peak was determined as the peak value of VO_2. This was due to the fact that only short-term (less than 30 s) increases in oxygen uptake occurred during the GBPT. BLC was obtained from the hyperaemic earlobe by an experienced medical laboratory technologist.

To determine offence and defence times, the time between the first and last contact on the padded roll mats (in defence) or touch fields (in offence) as well as for the fast breaks and running back (fast retreats) was measured. Throwing velocity and jump height during the jump throws were measured by calculation of 2D-position of the center of the ball and flight time from high-speed (200 frames per second) video files.

Results

Descriptive data - group means, standard deviations (±SD) and 95% confidence intervals (CI) - for all variables are depicted in Table 1 and 2. No significant differences between the different playing positions were found. However, both large and medium effect sizes were found in several of the variables. Some significant relationships in test results between the GBPT and the Yo-Yo IR1 test regarding the locomotive distances, VO_2-peak and HR were found. However, the Yo-Yo IR1 test results were not correlated to the team handball GBPT in any of the match-related activities in the GBPT that included technical playing actions. Several significant relationships between the sprint performance in the SSPT and in the Yo-Yo IR1 test performance and locomotive results in the GBPT, respectively, were demonstrated. However, the 30-m SSPT was

also not correlated to any of the team handball GBPT activities, which included technical playing actions.

Discussion

Yo-Yo intermittent recovery test (level 1)

The mean body mass, body height and age in the present group of players were 72,5 kg, 175 cm and 25 years, respectively, which is comparable to that of other female adult top-elite field team handball players from the Danish Premier Female Team Handball League (Michalsik et al., 2015c), National players from the First Spanish Team Handball League (Ferragut et al., 2018), and players in the Czech and the Serbian Female National Handball Team, respectively (Mala et al, 2015; Petković et al., 2019). The mean total running distance covered in the Yo-Yo IR1 test was ~1330 m,

Playing positions	**All players combined (n=23)**	**Backcourt players (n=10)**	**Wing players (n=7)**	**Pivots (n=6)**
Variables	Mean ± SD (95% CI)	Mean ± SD (95% CI)	Mean ± SD (95% CI)	Mean ± SD (95% CI)
Anthropometric variables				
Body mass (kg)	72.4 ± 9.1 (68.4-76.3)	72.6 ± 10.3 (65.2-80.0)	66.6 ± 5.3 (61.7-71.6)	78.6 ± 6.2 (71.4-85.8)
Body height (cm)	175.3 ± 7.6 (172-179)	175.6 ± 9.1 (169-182)	173.1 ± 8.2 (166-181)	177.3 ± 3.1 (175-183)
Age (years)	24.6 ± 3.3 (23.2-26.1)	25.5 ± 4.1 (22.6-28.4)	23.8 ± 3.3 (20.7-26.9)	24.2 ± 1.5 (22.6-25.9)
Yo-Yo intermittent recovery test, level 1				
Running distance (m)	1329 ± 236 (1227-1431)	1268 ± 263 (1080-1456)	1371 ± 89 (1290-1453)	1380 ± 287 (1050-1710)
Heart rate (beats·min^{-1})	193 ± 6 (185-190)	190 ± 7 (185-195)	196 ± 4 (188-201)	195 ± 6 (188-201)
30-m single sprint performance test				
15-m sprint time (s)	2.36 ± 0.11 (22.32-2.41)	2.35 ± 0.12 (2.27-2.44)	2.34 ± 0.07 (2.28-2.40)	2.41 ± 0.10

				(2.29-2.53)
30-m sprint time (s)	4.36 ± 0.18 (4.28-4.44)	4.33 ± 0.21 (4.18-4.48)	4.33 ± 0.11 (4.23-4.43)	4.46 ± 0.17 (4.25-4.67)

Playing positions	**All players combined (n=23)**	**Backcourt players (n=10)**	**Wing players (n=7)**	**Pivots (n=6)**
Variables	Mean ± SD (95% CI)	Mean ± SD (95% CI)	Mean ± SD (95% CI)	Mean ± SD (95% CI)
Team handball game-based performance test				
VO_2-peak (ml $O_2 \cdot min^{-1} \cdot kg^{-1}$)	62.9 ± 6.2 (60.2-65.6)	62.2 ± 4.6 (58.9-65.4)	60.7 ± 4.7 (56.3-65.0)	66.9 ± 8.1 (57.6-76.2)
Blood lactate concentration (mM)	9.6 ± 2.8 (8.4-10.8)	9.1 ± 3.0 (7.0-11.3)	9.5 ± 2.6 (7.1-12.0)	10.5 ± 2.8 (7.2-13.7)
Heart rate (beats·min^{-1})	188 ± 6 (185-190)	185 ± 6 (181-189)	190 ± 6 (185-195)	190 ± 4 (186-194)
Jump height (m)	0.32 ± 0.05 (0.30-0.35)	0.29 ± 0.04 (0.27-0.32)	0.35 ± 0.05 (0.30-0.39)	0.34 ± 0.06 (0.28-0.41)
Throwing velocity (m·s^{-1})	23.0 ± 1.7 (22.3-23.7)	23.3 ± 1.6 (22.2-24.4)	22.3 ± 1.8 (20.9-24.1)	23.1 ± 1.9 (20.9-25.4)
Defence time (s)	6.08 ± 0.24 ((5.98-6.19)	6.06 ± 0.26 (5.87-6.25)	6.11 ± 0.28 (5.86-6.37)	6.09 ± 0.16 (5.91-6.27)
Offence time (s)	6.13 ± 0.35 (5.98-6.28)	6.07 ± 0.29 (5.86-6.27)	6.30 ± 0.46 (5.87-6.73)	6.04 ± 0.25 (5.76-6.32)
10-m fast break time (s)	2.02 ± 0.11 (1.97-2.07)	2.00 ± 0.10 (1.92-2.07)	2.06 ± 0.14 (1.93-2.19)	2.00 ± 0.08

				(1.91-2.09)
20-m fast break time (s)				4.05 ± 0.20 (3.77-4.33)
	4.14 ± 0.22 (4.05-4.24)	4.09 ± 0.17 (3.97-4.22)	4.28 ± 0.23 (4.06-4.49)	
Fast retreat time (s)				2.16 ± 0.16 (1.97-2.34)
	2.24 ± 0.18 (2.17-2.32)	2.28 ± 0.13 (2.19-2.37)	2.26 ± 0.23 (2.05-2.48)	

Table 1. Anthropometric characteristics and results from the Yo-Yo intermittent recovery test, level 1 and the single 30-m sprint performance test for female adult top-elite field team handball players. Group means ± standard deviations (SD), and 95% confidence intervals (CI) for the main effect of measurements are specified.

Table 2. Results from the team handball game-based performance test for female adult top-elite field team handball players. Group means ± standard deviations (SD) and 95% confidence intervals (CI) for the main effect of measurements are specified**.**

which is somewhat lower (~ 7%) than previously reported in adult top-elite field team handball players from the Danish Premier Female Team Handball League (~1440 m, Michalsik et al., 2014) and the Brazilian Female National Handball Team (~1440 m, Michalsik, 2017), and also much less compared to female youth (mean age 17 years) top-elite international players (~1660 m, Moss et al., 2015).

One of the reasons for this difference could be due to the timing of the testing in the present study. The tests were carried out in the first days after the summer break, where the players were not used to team handball-like movements such as accelerations, decelerations and change of directions and high intensities in the same manner as during the competitive season. However, all the mentioned results for adult players are still lower than previous Yo-Yo IR1 test performances, for example measured in the Danish Female National Team, which won Olympic Gold in 2000 (~1510 m, mean body mass 68,5 kg, n=16), finished fourth in the World Championships in 2001 (~1675 m, mean body mass 65,5 kg, n=12) and won the European Championship in 2002 (~1540 m, mean body mass 66 kg, n=18) (Michalsik, 2003). This may indicate that the mean results of the Yo-Yo IR1 test has not improved significantly for at least female adult top-elite field team handball players the last couple of decades. One reason could be that the mean body mass (and hence probably the muscle mass) has increased markedly for female adult elite field players since the millennium (Michalsik, 2015c; Ferragut et al., 2018; Konstantinos et al., 2018; Martínez-Rodríguez et al., 2020).

Today´s female adult elite players are larger with increased body mass, which may have a negative impact on the Yo-Yo IR1 test performance due to the many repeated decelerations, accelerations and 180 degrees change of directions during the test. On the other hand, the increased body anthropometry will enhance the on-court performance in other important match activities as tackling, screening, blocking, throwing, jumping one-to-one situations and rapid change of directions and hence on the total performance during match-play. Muscle mass, maximum muscle

strength and muscle power are essential factors in modern female elite team handball (Marques et al., 2007; Granados et al., 2007; Vila et al., 2012; Granados et al., 2013; Michalsik et al., 2015c; Ferragut et al., 2018; Michalsik, 2018), which is required in actions like sprinting, one-to-one situations and rapid change of directions. In the present study, two players with high body mass (80.8 kg and 79.9 kg) performed badly in the Yo-Yo IR1 test (880 m and 1000 m). However, they both reached a high VO_2-peak (64.4 and 65.9 ml $O_2 \cdot min^{-1} \cdot kg^{-1}$) during the GBPT. Apparently, they can perform at a high level during competitive match-play, but are both too heavy to achieve a high total Yo-Yo IR1 running distance. In return, they will be strong in the numerous, crucial physical confrontations with the opponents.

Team handball game-based performance test

It is definitely not a surprise that the Yo-Yo IR1 total running distance corelated with the high intense locomotive measurements in the GBPT, considering the Yo-Yo IR1 test ends with repeated exercise bouts performed at very high intensity. In support of this notion, the Yo-Yo IR1 test performance was also significant correlated with 15-m and 30-m sprint time in the SSPT. Furthermore, the Yo-Yo IR1 test has been proved to measure the ability to repeatedly perform intermittent exercise with a high aerobic component towards the end of the test (Krustrup et al., 2003). Thus, a relationship between Yo-Yo IR1 total running distance and VO_2-peak and HR in the GBPT, respectively, and also between Yo-Yo IR1 HR and VO_2-peak in the GBPT was expected

In both tests, the aerobic component has been shown to approach maximal values. The player with the absolutely highest VO_2-peak (79.7 ml $O_2 \cdot min^{-1} \cdot kg^{-1}$) also covered the longest total running distance in the Yo-Yo IR1 test (1760 m). Interestingly, this world-class player was the only one who was able to perform the entire GBPT without a decrease in time in the offensive and defensive actions. A greater contribution from the aerobic metabolism apparently helped the player to avoid a decrease in the repeated, anaerobic actions throughout the entire test (Wagner et al., 2020). Noteworthy, this may also happen for elite players during real competitive matches. The high level of VO_2-peak in GBPT may enable a faster recovery during both training and match-play, and players will be able to perform on a higher level for a longer time.

30-m single sprint performance test

Thirty meter is the longest linear distance that team handball players may sprint during match-play (wing players). However, most sprints in team handball are of shorter distance and usually performed with changes of direction where the players may never reach their maximal sprint velocity (Michalsik et al., 2013, 2014, Luteberget & Spencer, 2017; Font et al, 2021). Consequently, a 15-m split sprint time was also measured in the present study. However, it may happen that team handball players (especially wing players) sprint for 30 m during match-play, for example, a goal scorer lying/standing in the goal area close to the goal when the opponents are taking a fast throw-off. The correlation between 15-m and 30-m sprint time was found to be very strong.

Several significant relationships between the sprint performance in the 30-m SSPT and in the Yo-Yo IR1 test performance and locomotive results in the GBPT, respectively, were

demonstrated. These correlations indicated that a 15-m sprint test are more relevant for team handball players than the 30-m sprint test, which is in agreement with results from previous studies regarding sprint distances covered during elite team handball match-play (Michalsik et al., 2013, 2014). This support previous findings showing that sprint training exercises in team handball primarily should target reaction speed and acceleration (i.e., rate of force development, RFD) rather than focus on maximum running speed (Michalsik et al., 2013, 2014; Michalsik, 2015).

Additionally, the 30-m SSPT was not correlated to any of the GBPT activities, which included technical playing actions like tackles, jumping and throwing with a ball (during defensive and offensive actions). These data suggest that on-court sprinting with and without a ball may not be the same, and that the 30-m SSPT only to a certain extent can measure the individual sprint capacity of elite team handball players who during match-play always are sprinting with or looking for the ball. The special movement pattern during training and matches is unique for team handball (specific team handball agility), and the high-intensity actions in team handball are performed very differently compared to the activity in a linear, 30-m sprint test.

Relationships between the various tests

Some significant relationships in test results between the GBPT and the Yo-Yo IR1 test regarding the locomotive distances, VO_2-peak and HR revealed that the Yo-Yo IR1 test were related to the GBPT and hereby also to the on-court performance in team handball match-play. However, it is notable that the Yo-Yo IR1 test results were not correlated to the GBPT in any of the match-related activities in the team handball GBPT that included technical playing actions like tackles, passes, jumping and shooting during specialized movements in offence and defence. The indirect validity of Yo-Yo IR1 test was in this study found to be only valid for locomotive activities, but not for team handball match-activities including technical playing actions, which otherwise is a very important part of elite team handball match performance (Granados et al., 2013; Wagner et al., 2014; Krüger et al., 2014; Michalsik, 2015b,c; Dello lacono et al., 2018; Vila & Ferragut, 2019; Akl et al., 2019; Bragazzi et al., 2020; Saavedra et al., 2020). The Yo-Yo IR1 test is solely a measure of some of locomotive activities used in team handball (e.g., not side-to-side change of directions and full-power, explosive accelerations). Moreover, using only locomotion match data seems to underestimate the physical demands of elite team handball match-play (Michalsik et al., 2013, 2014).

It seems reasonable to believe that it is decisive in team handball to use a test that contain all kinds of activities performed by the players during training and match-play. Using the Yo-Yo IR1 as a test to evaluate the physical capacities of elite team handball players will therefore not give a full picture of the level of physical performance of the players in question, instead, the test must be supplemented by others tests. This is an important finding in order to establish the potential use of the Yo-Yo IR1 test in elite team handball. Consequently, the results of the present study confirmed that the GBPT is better than the Yo-Yo IR1 test to measure all types of team handball actions i.e., both locomotive and technical match-related activities for female adult top-elite field team handball players.

Moreover, this study clearly indicated that team handball specific performance, as measured by the GBPT, and general physical performance, as measured by the Yo-Yo IR 1 test and the 30-m SSPT in the present study, are different elements in line with previously study data

(Wagner et al., 2019b). Using general tests for examining the physical performance of team handball players provides information of general, separate physical qualities, which may differ substantially from the physical on-court performance during match-play. This must be taken into consideration when evaluating the effect of relevant physical training, and when the coaches are using the results of general tests for the planning of optimal physical training regimens in elite team handball, which aims to increase the on-court performance during match-play.

Positional differences in test results

Surprisingly, no positional differences were demonstrated in all three physical tests. Potential positional differences in the team handball GBPT have not been examined before, but in regard to the Yo-Yo IR1 test and the 30-m SSPT, our study findings are in contrast to data from to previous studies in team handball (Michalsik et al., 2014; Krüger et al., 2014). However, there were several large effect sizes ($\eta^2 \geq 0.14$) especially in the GBPT (VO_2-peak, HR, jump height and 20-m fast break time), and numerous medium effect sizes ($\eta^2 \geq 0.06$) were also seen primarily in the Yo-Yo IR1 test (total running distance covered, HR) and in the 30-m SSPT (15-m and 30-m sprint time). This indicates that the sample size in the three groups (six pivots, seven wing players and ten backcourt players) in many cases was too small (Sullivan & Feinn, 2012). Thus, had the sample sizes been larger, significant positional differences would probably have been demonstrated, especially in the GBPT.

Conclusions

Both the Yo-Yo IR1 and the 30-m SSPT test results were not correlated to any of the team handball GBPT activities that included technical playing actions like tackles, passes, jumping and throwing with a ball during specialized movements in offence and defence. The present data collectively suggest that the Yo-Yo IR1 test performance does not reflect and measure the overall specific physical on-court performance of female elite team handball players, but solely an individual player's ability to repeatedly perform intermittent running exercise and the ability to recover from such intense exercise, which does not include technical playing actions. Additionally, the present data also suggest that on-court sprinting with and without a ball may not be the same, and that the 30-m SSPT only to a certain extent can measure the individual sprint capacity of elite team handball players who during match-play always are sprinting with or looking for the ball. Unexpectedly, no significant differences between the various playing positions were found either for the team handball GBPT, the 30-m SSPT and the Yo-Yo IR1 test.

The main study finding was that the results revealed that the team handball GBPT is better than the Yo-Yo IR1 test to measure and evaluate female adult top-elite field team handball players´ ability to perform physical match-related activities, including both locomotive and technical playing actions executed as during competitive match-play. Furthermore, this study also clearly indicated that team handball specific physical performance, as measured by the GBPT, and general physical performance, as measured by the Yo-Yo IR1 test and the 30-m SSPT, are different components.

Practical applications

To conduct the team handball GBPT requires many resources - intense planning, high advanced equipment, a lot of space, high knowledge and experience about physiology and testing, including blood sampling and portable respiratory gas exchange measurement of VO_2. In addition, the test is very time consuming, since only one player can be tested at a time. As a consequence, this is not a test which is suitable for regular testing of players in small clubs or at a lower performance level.

Instead, general physical tests such as the Yo-Yo IR1 test and the 30-m SSPT may be used. Both tests can test a whole team squad within an hour. Additionally, the Yo-Yo IR1 test, in particular, does not require a lot of equipment or human resources. It can easily be performed, also in clubs at a lower level. However, it must be emphasized that these tests have to be supplemented with other general tests, for example different strength and jumping tests, to give an overall picture of the physical capacity of team handball players. The 30-m sprint test can advantageously be reduced to a 20-m sprint test. It may also be performed several times with short breaks in between as a repeated sprint test in order to measure the repeatedly sprint ability of the players. Furthermore, it can be conducted with changes of directions or with offence and defence movements as a specific test for agility in team handball.

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PLANNING OF THE TRAINING IN TEAM HANDBALL

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Summary

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. Even though elite team handball is a team sport, the players must be loaded differently. 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 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 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.

Keywords: Individual planning, recovery, periodization, time course of physiological changes, tapering.

Introduction

In team handball, the training time for the physical training is limited, since the technical, tactical and mental aspects are of great importance for the playing performance, and therefore also need to be extensively trained. Thus, a thorough planning of the physical training is necessary in order to best utilize the sparse training time and to achieve variation and development, which can be of great importance for the players to retain the motivation to perform physical training. In order to plan an effective training course, it is necessary to make use of both practical experience and research-based knowledge. When planning, the trainers must constantly try to be open to new ideas and training methods. By changing the training methods and the planning, errors can occur, but this is crucial to be able to develop continuously.

Even though elite team handball is a team sport, match analyses have shown that physical training in modern elite team handball should be directed at the specific playing position and the players' individual physical capacity and need for recovery (Michalsik et al., 2013, 2014, 2015a,b,c). Furthermore, clear gender-specific differences in the physical demands of modern elite team handball have been demonstrated, strongly suggesting that central areas of physical training should be conducted differently in female elite team handball compared to male elite team handball

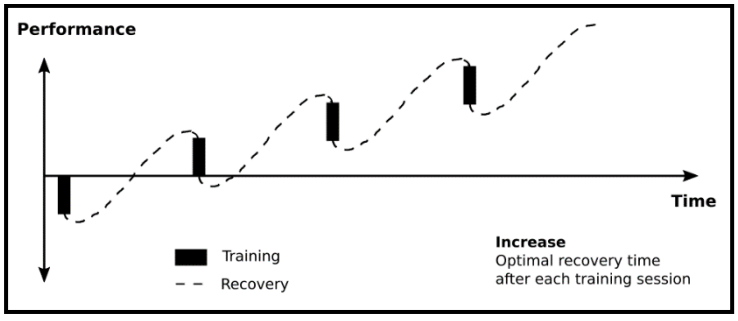
(Michalsik & Aagaard, 2015). Consequently, the aforementioned aspects must be taking into consideration, while designing physical training regimens for elite team handball players.

Any training schedule for a team handball player should be based on the analyses 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. This allows the trainer to assess which aspects the training should contain in particular. Based on the analyses, realistic objectives can be established. Even though elite team handball is a team sport, the players must be loaded differently. There is no training program that is optimal for everyone.

Training and recovery

Physical training helps to maintain or improve the physical capacity of players. It degrades the parts of the body that are exercised. In turn, the body is able to rebuild and adapt to the new physical demands. During training, a large amount of energy can be consumed, and the body's energy stores can be emptied. When the training is completed, the balance between degradation and formation of proteins is restored as the synthesis is being stimulated, and the degradation is returning to a normal level. Thus, after training during the recovery period, there is a net production of proteins. In addition, the energy stores will be rebuilt, and the liquid balance can also be fully restored. Furthermore, fatigue substances will be removed. Consequently, it is actually during breaks between training sessions that the improvement of the physical capacity occurs. Therefore, adequate recovery between training sessions is an important part of proper training planning.

The basic training principle is that the body should regularly be subjected to loads that differ from the loads it is normal used to (the overload principle). During the training session itself, the detrimental processes dominate, which briefly results in a decrease in performance. During the recovery period between training sessions, the building processes dominate, which results in the body not only is build up to the initial level, but also to above this (see Figure 1). This provides performance improvement compared to prior to start of the training session, which is called supercompensation (Gambetta, 2007). The right relationship between training and recovery is a prerequisite for achieving supercompensation and progress in physical fitness. It is therefore important to start the next training session at the time when the supercompensation is at its highest. The purpose of training is thus to load the body in order to obtain supercompensation.



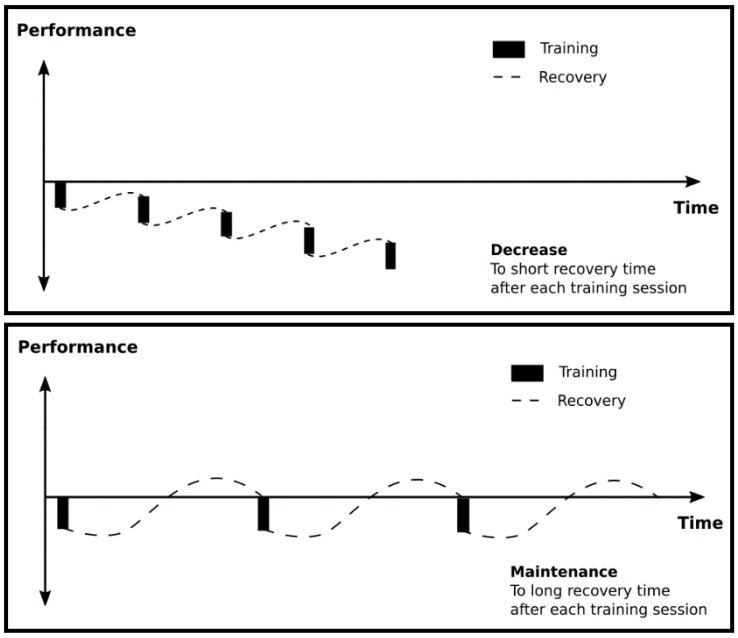


Figure 1. Theoretical examples of the interaction between training and recovery and thus on the body's adaptability to physical loading. Fitness enhancement is achieved by optimal recovery time after each training session, where supercompensation is obtained (top figure). Decrease in performance is caused by too short recovery time after each training session and without any supercompensation (middle figure). The physical fitness is maintained by too long recovery time between each training session, despite the fact that a supercompensation occurs (bottom figure).

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 outside stress factors such as health, lifestyle, nutrition, psychological stress and environment (Barnett, 2006; Erlacher et al., 2011; Lovell, 2011). The duration of the recovery process depends much on the training load. A large volume and high intensity of the training results in an extension of the time needed for recovery and adaptation, while the recovery takes place at a faster rate with a smaller volume and lower intensity of training.

However, it is not only the training volume, but also the players training level that plays a huge role in how long it takes to recover after training. Provided that the total volume of training is comparable, it takes all things being equal shortest time to recover from aerobic training, longer time after anaerobic training and longest time after intensive strength training. This means that in training planning, the timing and order of the different types of physical training must be carefully considered to ensure optimal recovery and adaptation. Recovery is dependent on the aforementioned factors, so it is not possible to specify exactly how often a player should train. For some players, the volume and intensity of the training will be optimal, whereas for others it will be too hard or too easy. The rate and quality of recovery from training and matches is extremely important for high performance in elite team handball, and optimal recovery may provide numerous benefits during repetitive high-level training and long tournaments.

An appropriate training plan is based on some general concepts and considerations. Some of them are mentioned here:

Training volume

The total training volume is an expression of the total training load the body is exposed to. It can be varied in several ways because the training volume (per week) = training duration (hours/ minutes/seconds) x training intensity (work per unit of time) x training frequency (number of training sessions per week). For example, 30 minutes of low-intensity aerobic training and 30 minutes of anaerobic production training do not provide the same training volume as the intensity of the training is very different. The weekly training volume during e.g., formal running with three training sessions of 30 minutes duration at a speed of 15 km per hour is 22.5 km.

Training progression

To ensure continuous development and progress in performance, the intensity or volume of training must be constantly increased concurrently with a fitness improvement, so that the body can be loaded according to the overload principle (see Figure 2). If this does not happen, the development in performance will stagnate. But the load must be increased at a pace, where the body is able to tolerate the physical demands.

Training specificity and variation

In order to achieve a high training effect, it is important that the training takes place in situations that are similar to the match situation as much as possible. The players simply become good at what they train. Unilateral training will eventually lead to body wear and result in injuries. Variety in training is also very important to maintain the players´ desire and motivation to train.

Training continuity

Training continuity means that the players need to train throughout the entire year. It always takes longer to increase a capacity than it takes to lose the adaptation that has occurred during training. Therefore, it is appropriate and important with some regularity with fewer training sessions in periods between competitive seasons, in off-season periods.

Training periodization

It is not possible for elite team handball players to be constantly at a top level during the entire competitive match season. The training must be periodized, so the players will reach the best possible performance in the most important competitions/matches 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 (Issurin, 2010). Training programs for elite team handball players should use periodization 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. Thus, the players get the opportunity to reach performance peaks and reduce the risk of collapse periods or that the players become overloaded.

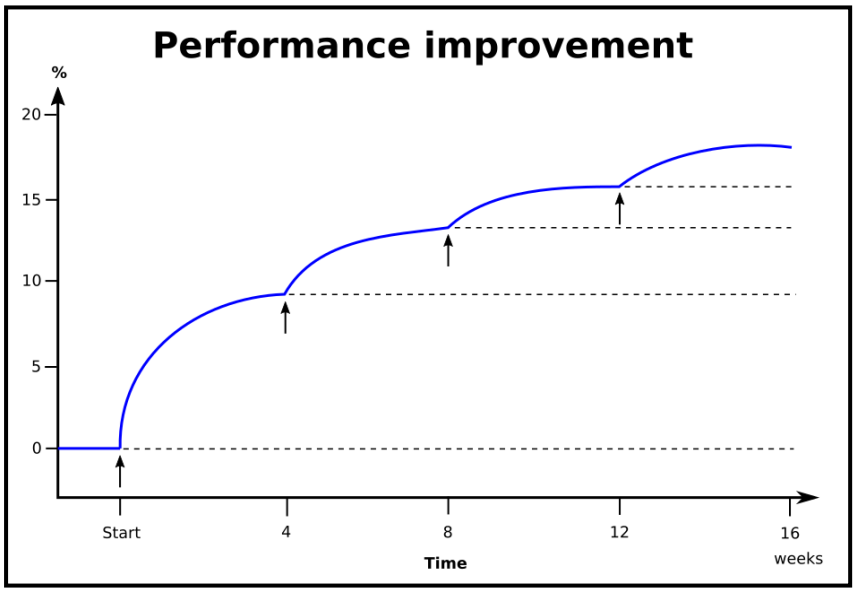


Figure 2. The figure shows the progress in aerobic performance after a long period of aerobic training. The arrows indicate that the intensity of the training was increased after 4, 8 and 12 weeks of training, respectively. This was done to ensure continuous progress in performance. Note that the progress was greatest at the beginning of the training course, where the output level was lowest.

There are different forms of periodization that can be combined during a specific training period. A known and used term is linear periodization (traditional periodization). This is a periodization model, which is characterized by decreasing training volume simultaneously with an increasing training intensity over time (Simão et al., 2012). As a starting point, the players begin with high volume and low intensity and gradually end up training with high intensity and low volume. Thus, a relatively linear increase in the training intensity and a relatively linear decrease in training volume occur during the period - hence the name - which is utilized to build a performance peak that can be achieved concurrently with a taper period (see Table 1).

Linear periodization can be used in sports where fewer competitions are held during a year (macrocycle) or within team handball for shorter periods, such as from the end of the season to the beginning of next season or during the winter break (mesocycle). However, it is not optimal if it is necessary to peak the physical performance multiple times during the season.

Another periodization model is block periodization (Issurin, 2008; Breil et al., 2010). This form of periodization is often used by elite athletes who want to peak in performance many times yearly (4-8 times a year). Consequently, it is suitable for team handball players with many matches during a season. This is a system of short training blocks with carefully selected content and focus on few physical qualities at a time. The blocks are trained in the correct order to achieve an accumulated training effect, so that the athlete is optimally prepared for the competition/match day (Rønnestad et al., 2014). This relatively short course can now be repeated and provides good opportunities for adjusting the training based on the actual performance.

	Muscle hypertrophy	Maximal muscle strength	Explosive muscle strength	Performance peak
Sets	3-5	3-5	2-4	1-3
Repetitions	8-12 RM	4-6 RM	2-4 RM	1-3 RM
Intensity	Low-moderate	Moderate	High	Very high
Volume	Very high	High	Moderate	Low

Table 1. Example of linear periodization (macro/mesocyclus) within strength training. Notably, gradually increase the intensity, gradually reduce the volume.

The following applies for block periodization:

- The training is varied in the different blocks (microcycles).
- The primary physical qualities of the first blocks must be maintained.
- The physical aspects where the physiological training adaptations last the longest (aerobic effect, basic strength) are usually trained primarily at the beginning of a block periodization, while elements such as anaerobic performance, speed and explosiveness, which change rapidly, are placed at the end.
- Everything is planned, so all parameters are peaking at the same time within a mesoblock of typically 4-6 weeks.

Reduction of the training volume (tapering)

In team handball, it is advisable to reduce the training volume (carry out a taper) during certain periods. The main reason for reducing the training volume for a period may be to optimize the performance in important upcoming matches or tournaments (Bosquet, 2007; Mujika, 2010). However, tapering is also sometimes performed to avoid getting into overtraining, to get time to work with other aspects of team handball e.g., technical elements, or to get rid of an injury as quickly as possible.

The most important facts about tapering are:

- Significant improvements in performance can be achieved by reducing the training volume in the last weeks up to a match/tournament. The reduction of training should take place gradually.
- Studies have shown that maintaining or increasing training intensity is necessary to avoid a decrease in physical performance during a period of reduced training.

- The prerequisite for effective tapering is that the players have achieved a sufficient physical level before the training volume is reduced.
- In team handball with a long competitive season, the players have the opportunity to change between periods with a large and a small training volume.
- Studies have shown that the reduced training volume results in supercompensation, while the high training intensity is stimulus enough to maintain the physical form. In addition, this reduces the risk of overtraining and injuries.

The elements that are crucial for the anaerobic performance are built up faster than the factors which are important for the aerobic performance (see Table 2). This means that for club team handball players it is not necessary to perform anaerobic training all year round, for example, the activity of the glycolytic enzymes can be significantly increased during a month of appropriate training. Thus, anaerobic training should only be intensified as the competition season approaches. This is very nice for the players, since anaerobic training is physically and mentally very demanding. Consequently, no systematic anaerobic training in the off-season period. Start only with on-court anaerobic training 4-6 weeks before a performance peak is needed (see Table 3).

Variable	**Time for a change**
Heart size	months - years
Blood volume	months
Muscle capillaries	(weeks) - months
Oxidative enzymes	days - months
Glycogen	weeks
Glycolytic enzymes	days - weeks
Buffer capacity	weeks
Na^+/K^+- pumps	weeks

Table 2. The time course of physiological changes for aerobic and anaerobic parameters, respectively.

Annual planning

Annual training planning should be based on when the most important matches or tournaments take place. In order to make the planning clearer, the year is divided into smaller periods for which partial aims are set and agreed concerning which type of training should be prioritized when and to what extent. Hereafter, the more detailed weekly planning can be done. Here emphasis should be placed on training periodization. Finally, the content of each training session can be planned. The season will normally be divided into the following periods, which can vary widely in length depending on the specific season:

- Maintenance period (recovery or off-season period) - physical and mental recovery.
- Preparation period - developing the physical capacity.
- Pre-competition period - functional training, preparing for the season.
- Competition period (tournament period) - maintaining/increasing a high level of playing performance.

The most important elements of an annual plan for aerobic and anaerobic training are:

- Aerobic training is performed regularly every week of the year, as it takes a long time to achieve a training effect on the central (circulation and respiration) factors.
- During the pre-competition and competition period, aerobic high-intensity training is prioritized at the expense of aerobic moderate-intensity training, which at the same time gives more time to train other aspects of team handball.
- The maintenance and preparation period contain limited amounts of anaerobic training.
- For top-level players, anaerobic training for the last 4-8 weeks up to the competition season (during the pre-competition period) is performed up to 3-5 times per week. During the competition season, anaerobic training is performed 1-3 times per week depending on the match schedule.

Aerobic training	**Pre-season**	**Competition season first half**	**Between season halves**	**Competition season second half**
Moderate-intensity training	3344 4445 5544 32	3333 3323 3232	4443 32	3333 3323 3443 3322
High-intensity training	2223 3234 4445 55	5454 5454 5454	3345 54	5445 4445 5555 4544
Anaerobic training	**Pre-season**	**Competition season first half**	**Between season halves**	**Competition season second half**
Speed endurance training	1111 1111 2345 55	5454 3545 5455	1134 55	5454 5455 4345 5454
Speed training	1111 1111 3445 55	5555 5554 5545	1345 55	5555 5555 5454 5545

1: Very low priority (need not to be trained)

2: Low priority (can be trained)
3: Moderate priority (should be trained)
4: High priority (must be trained)
5: Very high priority (need to be trained)

Table 3. Overall planning of aerobic and anaerobic training for each week during an entire season in team handball for a male elite team. One number represents one week of training, i.e., four numbers represent one month of training. The pre-season period includes the maintenance-, the preparation- and the pre-competition period, respectively. The length of the different periods may vary between different countries. Notable, the anaerobic training has a very low priority in the beginning and the middle of the pre-season (off-season) period.

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.

Specific aspects in team handball planning of the physical training

- A significant part of the physical training should be performed with the ball, since the specific muscle groups used in team handball then will be trained.
- To be sure to peak the team performance at the most important times in the competitive season, it is necessary to select 2-3 periods as the most significant.
- The competitive period will often be divided into two halves due to national team activities (WC, EC etc.), so there will be an opportunity to periodize the training for the club players.
- The physical training planning must take into consideration those players who do not play much in competitive matches etc.
- It is important to dose the training sensibly in the weeks where two or more matches are played per week.
- Attention must be paid to the players who play both on the club team and at various national teams to ensure they are not overloaded.
- National team players must often be in top form at a time other than club players. Special considerations must be taken.
- The most important period in planning of the year for elite team handball players is the off-season period. In this period, all aspects of physical fitness can be improved, which is a precondition for being able to tolerate to train at high intensity and with a large total volume and to play many matches on a high level during the competition period. The players “train to be able to tolerate to train” in order to improve the performance and also to prevent overload and injuries. During the off-season period, top-elite team handball players should train more and with a better planning, often two times each day.

NEW LEARNING ENVIRONMENTS IN EDUCATION – CHALLENGES FOR HANDBALL

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Abstract

The continuous need for education (coach education programs and long-life learning education programs) and the significant changes in National and European policies and regulations overseeing sports coaching and training requires the adjustment of teaching models and methods to the needs and potential of lecturers, coaches, and technology.
In the last years some coaches education programs begun to use e-learning, distance learning and virtual environments in their teaching methods. It's important to understand if the use of this new teaching processes influence the coach education models and how they influence it.
With this preliminary study we present some ideas how the use of e-learning, distance learning and virtual environments influence the coach education models.
Through an exhaustive documental research, we could achieve some data and results of studies about the use of e-learning and virtual environments in coach education programs.
Motivation, success, new perspectives, teamwork, different materials are some of the ideas that are presented by student-coaches and lectures in the studies we analysed. With these ideas it's possible to build coach education models based on this new teaching models and methods.

Keywords: Coach education, e-learning, distance learning, virtual environments, education models

Introduction

Although in the last years e-learning, distance learning and virtual environments have been introduced by coaches in their teaching methods, the importance of this approach has been upgraded by the pandemics of SARS COV2.

The unequalled growth of online learning in recent years (Aparício & Bacao, 2013; Chen et al., 2010; Guo et al., 2016; Schwarz et al., 2015; Shao, 2018; Steiner et al., 2013) has been boosted by these phenomena. In fact, suddenly, the quarantine in most states of the world, the constant need to focus on public health issues, have imprinted in various institutions note only in traditional education, but also in multinational corporations, law enforcement, health, sports, and without doubt the coaches, the need to change. That change involved the use of virtual environments of non-traditional learning, which involved indexing bytes of information on the network, following the proliferation of virtual environments, conference calls, reunions, and lectures.

It is not our place here to reflect on the contours of this multifaceted intrusion in the domestic dynamics. What is certain is that from one day to the next, everything changed, and with that coach's education models.

In fact, if the classification of the collection is Education or Pedagogy we take for granted the aphorism that teaching and learning are inseparable processes (Ward, 2012) or, in the words of Freire (1996) that teaching is the consecration of learning.

It has been known that satisfaction with learning is improving, and is part of people's life, whether is for basic, university, coaching and training, or life-long education in organizational context, or simply for pleasure.

Bloom Taxonomy and technology

Technology and distance learning should have the same SCRUM principle, to develop agilely the complex products that arise from the transmission of knowledge, whose societal dynamics leads to more complex and adaptive processes. Those are the element of value creation, when the human being is transformed, with tools for analysis and criticism, playing, and developing mentally and physical, generating evolution.

In fact, traditional teaching is increasingly supported by technological content (Sun et al., 2008; Wang, 2003) which directly or indirectly affects education and the respective teaching-learning processes.

Thus, e-learning emerges as the paradigm of today's education with a 35.6% growth (Sun et al., 2008), which has been consolidated with the SARS - COVID19 pandemic, as a normality after the definition of e-learning emergency protocols for teaching, for the redefinition in the form of educational interaction, from the initial levels of education to the higher education level (Murphy, 2020).

The concept of e-learning in an evolutionary concept that derives from the overall computer-assisted instruction, learning, or every description that mentions the learning with the support of computer, that helps the practice, tutorial approaches, and engagement with the tasks, that might be asynchronous or synchronous (Zinn, 2000). Since the begging the usefulness of the computer assisted learning has been debated and the common ground between every debate is the hardware, computer that allows the performance and the interacting between givers and receivers of knowledge (Bain et al., 1998; Bong, 1998; Fiol & Lyles,1985; Grabinger & Dunlap, 1995; Godwin-Jones, 2012; 1981; Hart, Levy, 1997; Ismail, 2001; Kemeny & Kurtz, 1968; Lee & Lee, 2008; Lee et al., 2005; Ludvigsen & Morch, 2010; McAuley et al., 2010; A. Morch, 2012; Rosenberg, 2001; Rovai, 2004; Sthal et al., 2006; Zinn, 2000).

Due to the misbelieve that online learning is the same that e-learning, it is important to start by clarifying that online learning refers to acquiring knowledge on the internet, without a given time,

a place or a region (Sun et al., 2008). On the other hand, e-learning is a more complex-driven concept that involves and is sustained by learning technologies, instructional strategies and pedagogical models or constructs (Dabbagh, 2005). The author called a theory-based approach, that congregates collaboration, articulation reflection, problem solving, exploration – Instructional strategies – in an environment of asynchronous od synchronous communication tools, multimedia tools, course management systems (such as moodle, nau, sharepoint, Leed, Microsoft teams, among others) – Learning technologies – embedded by Pedagogical models or constructs, that considers open or flexible learning, distributed learning, knowledge building communities.

Because e-learning conveys into the enhancement of individual and organizational environment, by using internet technologies that create and deliver a rich learning environment (Rosenberg, 2001), its use is fundamental in every level of education, sport, or other activity. The learning might be more "activist", "reflector", "theorist" or "pragmatist", that permits to undergo the experience, reflecting on it, concluding, and putting in practice the learnings (Kolb's learning cycle, cited in Miniano & Rui, 2020).

A reflexion must be taken upon, because the concept of online learning might overlap the concept of distance learning. In earlier 80's Keegan's presented the concept of distance education that allowed to congregate of "quasi-separation of teacher and learner", use of technical media, two-way communication (Keegan, 1980, 1986, cited in Rumble, 1989, p. 10). More recently the concept presented by Csarotti et al. (2002) mentioned that the physical void between students and teachers is filled by means of technological resources.

However due to the evolution of technology, the notion of private study situation was overcome, and the stiffness of the concept turned into a more complex, broader, and appealing form of learning.

Even though distance learning "had its beginning as a paper-intensive media that predates the computer" now, as then it conveys the needs and fills the void of a "self-paced, individualized instructional regimen" (Tomei, 2017, p. XIIII).

Both involves the elements of behaviorism (matured from behavioral roots as text-based content), cognitivism (epitomized by LMS learning platforms, because it's a context-based instructional presentation) till the humanism, by the personalization of knowledge, considering the interactive synchronous package, and a face-to-face interactive environment promoted by virtual technology.

The fundamental fact is that the concept is still in its evolutionary phase (Aparicio & Bacao, 2013; Aparicio et al., 2016), but no matter where the concept will guide us, main elements are common to all, technology, accessibility, new methods, internet, globalization of knowledge. This is due to the flexibility of technology in all its forms, including virtual environments, that allows to overthrow the spatial, time restriction, and human physical possibilities.

Sports and virtual environments: The importance of technology

Cogitating that the process of online, distance, e-learning, and b-learning are complemented by computer it can be added to the education models the virtual environments. Engaging in different methods of learning can help players, students, and coaches to be more effective, independent, and self-motivated in this process. The technology assisted learning has its benefits, first its a way of reducing of self-isolation, and enhance knowledge to stay relevant, up-to-date, and aware of the changes and sports evolution. Though the desirable positive outcomes, it must be a complement to the more traditional face-to-face education, where depth, convenience and human connection is of major added value, in the build of human beings.

The up surge of virtual environments (VE) in learning is not a recent process, although the pandemics helped to accelerate the need of tools and convergence of methods, that can help different actors to keep the focus in training and the development of skills and made it as "technologies momentum" (Zhang et al., 2006, p. 15).
From the traditional input devices (2D) to three-dimensional ones (3D), of virtual environments to immersive ones, provided by virtual reality (VR) (Mendes et al., 2018), and augmented reality (AR) (Uhm, et al., 2019) are natural resources and conjoint ground for the incorporation, without fear, of these technologies in sports, and its education/learning models.

Second life is one good example of a virtual three-dimensional world that provided alternative realities, in which people interacted, with the reproduction of game segments, dynamics and features, which increased the understanding of the game itself (Lopes et al., 2009).

This kind of environment creates a sense of presence which has a neurophysiological impact (Uhm et al., 2019). In fact, the use of VR is used "due to immersion, interaction, and visualization (Petri, et al., 2018, p. 2), in a sterilized "world", where manipulations of the virtual characters, weather conditions, sports hall infrastructures, fans, can be made and controlled (Faure et al., 2020). In mid-90's Mine (1995) already pointed out that movement, selection, manipulation and scaling were the underlying mentors of VE. In our opinion they help to create the perfect condition for a better understanding of reactions and strategies in sports.

As so, providing interactivity between coaches and players (teachers and students) is looked-for because has positive effects in education and training. The reinforcement of contents, skills and cognitive perceptual skills in sports (Gray, 2019), provided by virtual environments upheavals the multisensory state of awareness by allowing a "more vivid and fascinating presentations" (Zhang et al., 2006), and scenarios that are more easily reproduced in virtual world that in real world, and that allow the repetition without physical, and material restrains.

To state the importance of this new learning method, virtual environments are prom in studies and literature reviews in many sports, such as endurance sports (Neumann, 2017), soccer (Wirth, 2018), surfing (Farley et al., 2020) and team ball sports (Faure et al., 2020).

Handball challenges: The future direction

Handball faces a landmark for strategies of training which could make a significant contribution towards improving the quality of education, teaching, and access to the sport. When considering the future of handball, it is important to consider all the trends related to coaching that are already influencing current trends and planning. As so memorizing facts or instructions will be of added value, while exploiting information for scrutiny and decision-making process will be a core aptitude for coach, educational and professional evolution.

Studies shown that introducing new learning environments in education students are more prom to work on the subject, more satisfied with the process (Dvorak & Burchanan, 2002). This fact is also seen in training of handball coaches that involved hybrid training, whereas the satisfaction in the process met is expectations in turns of knowledge, tools and dynamization of process (Theunissen, Delfosse, & Cloes, 2016).

The insights provided by studies (Bideau et al., 2003; Bideau et al., 2004; Bolte et al., 2020; Fan & Li, 2021; Lochman et al., 2021) consider that the realism of VR is enough to promote effectiveness of the movement, to understand and anticipate the interactions between players and to improve training.

New learning environments in sports are exponentially increased by the recurrence to technology because they open more opportunities, and access to learning and training. As a motor of development, it offers the possibility to upgrade and update information, retraining and individual or collective enhancement, improves cost efficiency of scholastic resources, enhances, and consolidates capacity.

The accessibility to a variety of instruments, techniques, and diversified approaches to Handball learning might better adjust to the needs of each of the players, allowing the coaches to personalize the intervention in each one of them improving their performance and capabilities. In fact, not all the students and players learn the same way. Some learn from repetition, others from visual stimuli, and others by listening or interacting with a computer program or virtual reality.

E-learning, b-learning, virtual environments, are considered the present and the future of learning/coaching and a vital part of any type of educational/learning process in the future.

Its use, and a policy of self-made, personalized, customized educational policies, and management systems could amplify the possibility to improve results, interact with different actors, leading to a more efficient system.

The incorporation of different methodologies conveys to a multisensory system of learning that takes advantage of every single element of human morphology and learning capabilities, providing more flexibility, freedom of self-directed learning without compromising the students/players in anyway.

Combining strategies to develop perceptual-cognitive skills that concurs to psychological fidelity and physical skills, for the physical fidelity is the core of sports and handball evolution. None of the elements can be underestimated, and must work as a partnership for life, taking advantage of the benefits that traditional, virtual learning and environments provide.

The path of technology is grounded is the mainstream of human life and evolution, and it's a trend that will not fade away, because online learning and its tolls have finally come of age. Is up to Handball structure to face these challenges, as to grow and take its place as the sport mentor, being the first to assume that the change and use of new tools are of added value to coaches and players.

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THE IMPORTANCE OF HIP MOVEMENT DURING LEG-KICK SAVES: A COMPARISON BETWEEN AN ADULT & FIVE U18 FEMALE GOALKEEPERS

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Summary

This explorative study compared the leg-kick block of an adult female Danish national A-team goalkeeper and five elite U18 female goalkeepers. The adult goalkeeper's movement pattern was distinguished by a higher amount of concentric work from the muscles around the hip, and as a result she reached the highest foot position and velocity. Indicating that coaches should focus on increasing hip flexion and outwards rotation to improve goalkeepers' leg-kick height and velocity.

Keywords: Goalkeeper, Biomechanics, Movement Analysis, Performance

Introduction

It is well recognized within the handball community, and documented in the scientific literature [1,2], that goalkeeper's performance is highly associated with match/tournament success in elite handball. Goalkeepers performance is influenced by their ability to anticipate and/or read the game development and particularly the movement of attacking playing. And subsequently use this information to position themselves in a body posture that enables them to block the shot with their arms and/or legs. Whilst anticipation skills might be the most important factor for successful goalkeeping performance [3,4], fast reaction times, agility, flexibility and movement coordination (technique) is required to block the shot from a facing attacker.

Goalkeepers use a range of traditional and untraditional movements patterns to block the ball with their hands, arms and/or feet. The leg-kick block is among the more traditional techniques and is characterized by a single-leg stance (Figure 1), whilst the opposite leg is lifted from the ground to block the area around the goalkeeper's waist or the top corner of the goal, in combination with the arm/hand. The leg-kick is a fundamental goalkeeper-specific skill frequently employed by both male and female goalkeepers at all levels to block 7 meters throws, fast breaks or shots from wing players.

Nevertheless, the biomechanical movement pattern of the handball-specific leg-kick movement is yet to be established in the current literature. Therefore, the aim of this explorative study was to compare the leg-kick movement pattern of a female national A-team goalkeeper and five elite U18 female goalkeepers.

Methods

A female Danish national A-team goalkeeper and five elite U18 female goalkeepers volunteered to participate in this study (Table 1). The goalkeepers attended a single test session in a biomechanical movement analysis laboratory, where they completed a total of 6 maximal simulated leg-kicks (3 trials for each leg).

The goalkeeper's lower limb kinematics was recorded at 200Hz with an 8-camera Vicon motion capture system (Vicon Motion Systems Ltd, Oxford, UK). More specific from 24 retroreflective markers attached to the pelvis, lower limbs and the goalkeepers' shoes [5]. Kinematic marker trajectory data were filtered with a Woltring cubic spline filter using inherent Vicon Plug-in-Gait software (Vicon Nexus 2.11).

Table 1. Age and anthropometric profiles of the adult and five U18 goalkeepers.

	A-team Goalkeeper	**Elite U18 Goalkeepers**				
		A	**B**	**C**	**D**	**E**
Age (yr.)	21	18	18	17	18	17
Body height (cm)	185.1	167.6	173.3	172.6	173.3	160.2
Leg length (cm)	101	84	88.5	89.5	90.5	80
Body mass (kg)	84.7	63.0	62.7	58.9	64.4	57.8

Three-dimensional hip and knee joint angles were calculated for the kicking leg, from movement onset (defined as the first timeframe where the vertical heel marker was 3 standard deviations higher than its static position) to the timeframe where the heel marker reached its maximal vertical position (Figure 1). Subsequently, local maxima of the goalkeeper's hip flexion, abduction and outwards rotation, knee flexion and extension angles were calculated for each trial.

Additionally, net positive (concentric) and negative (eccentric) joint work was calculated for the hip, knee and ankle joints by integrating the positive and negative parts of the instantaneous joint power curves with respect to time, respectively [6] . The total amount of positive and negative lower limb joint work produced by the kicking leg were subsequently calculated as the sum of the individual joint's (hip, knee, and ankle) work.

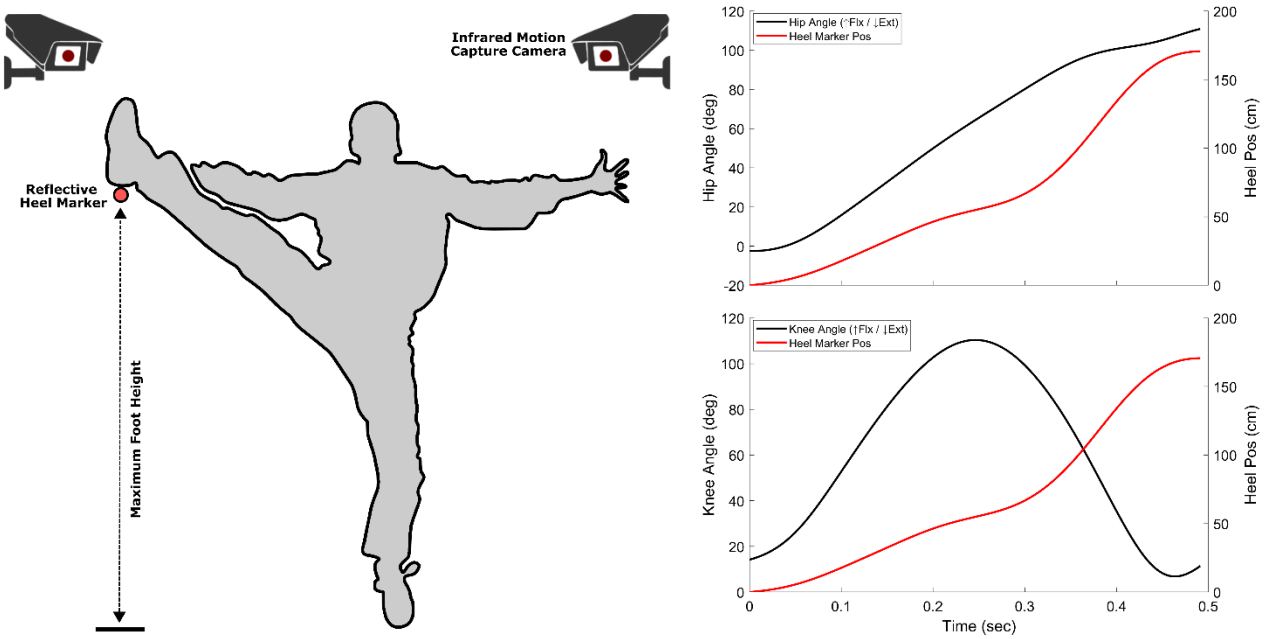

Figure 4. Illustration of the leg-kick movement recorded with a 3D motion capture system (left side). Representative examples of the vertical heel marker position, sagittal plane hip and knee joint angles for the adult A-team goalkeeper (right side).

Results & Discussion

The adult goalkeeper was on average able to lift both feet (Peak Pos) to 95-97% of her body height and reached maximum foot velocity (Peak Vel) of 8.4 and 8.5 m/s during the leg-kick (Table 2). In comparison, the U18 goalkeepers' average foot height ranged from 72% to 90% of their body height and the generally reached lower maximum foot velocities (between 6.0-7.7 m/s).

Table 2. Selected output variables (mean ± SD) for the goalkeepers' right (R) and left (L) leg.

Heel Marker Data	A-team Goalkeeper	Elite U18 Goalkeepers A	B	C	D	E
Peak Pos (%Sub Height)	R: 97 ± 1 L: 95 ± 1	R: 83 ± 1 L: 82 ± 2	R: 81 ± 2 L: 83 ± 1	R: 78 ± 1 L: 74 ± 3	R: 72 ± 1 L: 72 ± 3	R: 90 ± 1 L: 90 ± 1
Time To Peak Pos (ms)	R: 488 ± 5 L: 480 ± 12	R: 463 ± 6 L: 463 ± 5	R: 407 ± 6 L: 420 ± 8	R: 440 ± 18 L: 450 ± 11	R: 415 ± 1 L: 422 ± 6	R: 413 ± 22 L: 418 ± 27
Peak Vel (m/s)	R: 8.4 ± 0.2 L: 8.5 ± 0.3	R: 6.0 ± 0.1 L: 6.0 ± 0.4	R: 8.3 ± 0.1 L: 7.2 ± 0.7	R: 7.6 ± 0.1 L: 6.3 ± 0.2	R: 7.2 ± 0.1 L: 6.7 ± 0.1	R: 6.9 ± 0.4 L: 7.7 ± 0.7
Peak Joint Angles (deg)						
Hip Flex	R: 112 ± 1 L: 117 ± 1	R: 104 ± 3 L: 82 ± 1	R: 86 ± 3 L: 93 ± 5	R: 84 ± 4 L: 96 ± 2	R: 81 ± 1 L: 81 ± 1	R: 104 ± 2 L: 115 ± 5
Hip Abd	R: 49 ± 1 L: 55 ± 1	R: 46 ± 1 L: 53 ± 3	R: 45 ± 1 L: 52 ± 1	R: 48 ± 2 L: 48 ± 1	R: 41 ± 1 L: 42 ± 1	R: 54 ± 1 L: 48 ± 1
Hip OutRot	R: 26 ± 3 L: 33 ± 2	R: 6 ± 2 L: 24 ± 2	R: 9 ± 2 L: 10 ± 2	R: 14 ± 1 L: 17 ± 1	R: 6 ± 3 L: 3 ± 1	R: 25 ± 2 L: 16 ± 4
Knee Flex	R: 110 ± 4 L: 94 ± 4	R: 97 ± 5 L: 92 ± 1	R: 118 ± 1 L: 95 ± 6	R: 113 ± 4 L: 119 ± 1	R: 94 ± 5 L: 99 ± 7	R: 108 ± 2 L: 117 ± 4
Knee Ext	R: 7 ± 3 L: 4 ± 2	R: 3 ± 1 L: -1 ± 2	R: -7 ± 1 L: -5 ± 1	R: -3 ± 0 L: 1 ± 2	R: -2 ± 3 L: -1 ± 1	R: 2 ± 3 L: 2 ± 6

Pos: vertical position; Vel: vertical velocity; Flex: flexion; Abd: Abduction; OutRot: outwards rotation.

The adult goalkeeper's leg-kick was generally characterized by higher peak hip flexion (average values between 112 and 117 deg) and outwards rotation (between 33 and 26 deg) compared to the U18 goalkeepers (Table 2). Furthermore, the movement analysis revealed that the adult goalkeeper generated 69.5% of the total joint work (Figure 2), required to lift her kicking leg, from the hip joint (knee: 22.7%; ankle: 7.8%). Whereas, the U18 goalkeepers almost generated a similar amount of positive joint work from the muscles around the hip (between 36.7 and 56.0%) and knee (between 34.7 and 57.5%) joints. Finally, high eccentric demands were observed for the hamstring

muscles, with the knee joint accounting for the majority of negative joint work (55 – 73% of the total negative joint work) during the whiplash like movement of the lower leg in the final stage of the movement.

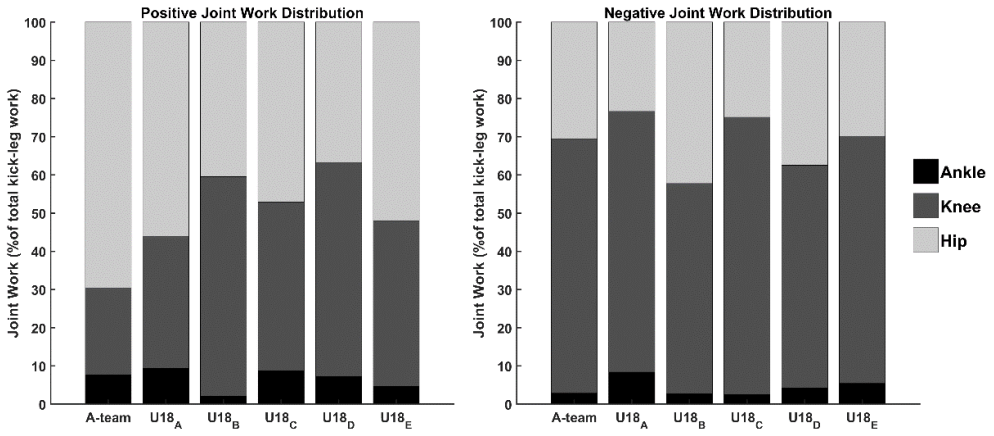

Figure 5. The goalkeepers average positive (concentric) and negative (eccentric) joint work distribution.

The ability to lift the feet/leg higher and faster may enable goalkeepers to cover a large area of the goal, but we acknowledge that the ability to lift the leg higher is not necessarily directly associated with higher saving rates. Similarly, we acknowledge that variation of the leg-kick movement exist, and that a high knee/thigh position, rather than a high foot position, might be more favorable when the aim is to block the area between the goalkeeper waist and arms.

Conclusions

The findings of the present study indicate the importance of hip flexion and outwards rotation to increase the maximal foot height and velocity during leg-kick blocks. Thus, coaches should focus on hip flexibility and movement when working with young developing female goalkeepers. Though, coaches should not neglect the combined hip-knee joint coordination, including the whiplash like knee extension in the last part of kick, to improve handball goalkeepers' leg-kick performance.

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CHARACTERIZATION OF ASIAN HANDBALL BASES ON A COMPARATIVE ANALYSIS OF THE REGION'S TWO LEADING NATIONAL TEAMS

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Summary

We compared the Japanese and the South Korean men's national handball teams through their performance in 6-6 matches at the 2019- and 2021-Men's Handball World Championships. Our goal was to identify some variables that can describe differences between their playing styles. Data was recorded and analyzed using the XPS Sideline system. The data sheets were downloaded from the official website of the IHF (International Handball Federation). The results showed that the South Korean team finishes the organized attacks 2-3 seconds earlier than the Japanese, utilizes parallel thrust play and feints significantly more often than the Japanese team. On the other hand, Japan tries to create advantage position change between the back players and/or including the pivot 90% more than the South Korean team. The results showed a clear difference in playing style between the Japanese and South Korean team. While Japan is trying to finish the organized attacks from many position changes, the South Korean backcourt players are creating chances with frequent feinting and quick parallel passes without changing positions.

Keywords: handball, playing style, comparison, Japan, South Korea

Introduction

The spread of the game of handball from Europe can be traced to other continents. The Asian region rivals other continents in terms of size, but, as in European practice, we can observe different national handball cultures. If we compare only the national teams of the Middle East and the Far East, we can already see significant differences, but if we look only at the two dominant countries of the latter region, we believe we can also find major differences between the big rivals, Japan and South Korea. Japan has a long and rich handball history, but never was able to obtain a medal in a world level adult competition. Tokyo 2020 Olympic Games gave a chance to their female and male national teams to compete in an Olympic tournament after decades (45 and 33 years) with two European head coaches. Japan has been trying to elevate its competitiveness with coaches from Europe from time to time. Due to our first-hand knowledge and continuous experience, we chose the men handball teams for comparison. The Japanese men's national team achieved the historical win against South Korea after 27 years lead by Carlos Ortega. South Korea had won a gold (women's team) and a silver medal (men's team) first at the Seoul Olympic Games in 1988 and has been dominating the Asian handball since, especially their female national teams. Unlike Japan, the South Korean national teams have been coached only by Korean coaches. Although both teams may seem playing a similar type of handball, usually described by coaches, as "quick". We assumed that Japan with the European influence would show different style in

attack compared to the South Korean counterpart. This study aimed to identify some indicators in organized attack, that can describe those differences.
This study does not aim to clarify success rate of all the indicators. More focused on the occurrence rate of certain indicators in organized attack, that project each team's intentions. Since we were unable to find any previous scientific research on playing styles in handball, we tried to find qualitative indicators that can show difference in several aspects of speed (fast breaks, lengths of the organized attacks), and strategies in organized attack.
Our hypotheses (H) were the followings:
The Japanese team tries to create a situation (attack finishing) with faster flowing attacks than the South Korean team (H1). The South Korean team prioritizes set attack plays involving four or more players, the Japanese team organizes attacks based more on group combinations of four or less players for creating goal-scoring opportunities (H2). The South Korean team utilizes parallel thrust without changing positions more often, than the Japanese team for creating attack finishing situations (H3). Both national teams use fast counterattacks in the same degree (occurrence) and success rate(H4).

Methods

The sample entities were comprised of a total of 24 matches, 696 scenes of the 2019 and 2021 Men's Handball World Championships. These are the most recent championships where both teams competed. In 2019 South Korea participated with an all-Korean team, but North Korean players did not play significant role in the team, they ended up on the 22nd place. Japan on the other hand, participated with the help of the IHF wild card and finished as 24th. 2021 World Championship was an unordinary tournament, in the middle of the pandemic with the participation of 32 teams first time in handball history. Japan finished 19th, a young Korean team ended 31st.
Our research method had been data analysis using statistical data sheets from the tournament in addition to the video of the matches. Data from the videos was recorded using the XPS Sideline system. The data sheets were downloaded from the official website of the IHF (International Handball Federation).
Data processing
Beside the descriptive statistics with its fundamental measures, hypothesized significant differences between data were analyzed using a 2way-Anova test, and χ-square test with a significance value of 0.5

Results

Table one shows the result of the descriptive statistics in regard with the average lengths of the organized attacks in seconds.

Table 1. Average organized attacking time (H1)

Year	2019	2021	Total Avg.
Japan	37±42 sec.	34±51 sec.	35.5 sec
South Korea	39±98 sec.	41±54 sec.	40 sec.

Table 2. ANOVA Effect Test (H1)

Source	DF	Sum of Squaures	Mean Square	F Ratio	Prob > F
Year	1	1	2082.3129	9.1555	0.0026
Team	1	1	1517.4119	6.6718	0.01
Year*Team	1	1	1.8363	0.0081	0.9284

ANOVA test was used to determine the significance of the differences that were found in organized attack lengths.

Table 3. displays the descriptive analysis regarding the number of the players who are involved in the last active preparatory phase of the organized attacks.

Table 3. Total number of related players (H2)

South Korea	Number of players	1	2	3	4	5	6
	Grand Total	6	58	103	136	47	2
Japan	Number of players	1	2	3	4	5	6
	Grand Total	6	29	101	143	53	12

1-6 Number of players involved in the last active phase of the attack before the finishing (individual, group or team tactical element)

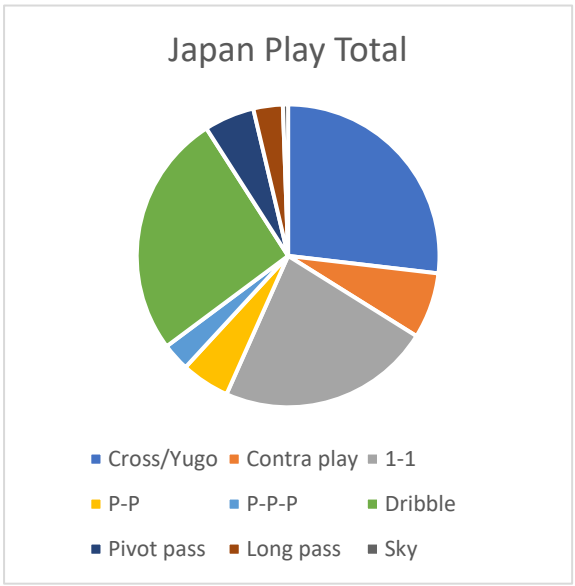
Beside the easily measurable quantitative indicators, we have chosen some qualitative indicators too, which can describe certain elements of play (table 4).

Table 4. Total occurance number of the qualitative indicators (H3)

South Korea	Indicator	Cross / Yugo	Contra play	1-1	P-P	P-P-P	Dribble	Pivot pass	Long pass	Sky
	Grand Total	74	56	179	83	20	97	62	7	2
Japan	Indicator	Cross / Yugo	Contra play	1-1	P-P	P-P-P	Dribble	Pivot pass	Long pass	Sky
	Grand Total	145	38	123	28	16	141	29	17	3

Cross/Yugo Crossing with or without the ball; **Contra play** Quick contra pass or movement without feinting; **1-1** Feinting with the ball; **P-P** Two continuous parallel passes (parallel thrust) without changing positions; **P-P-P** Three or more continuous parallel passes (parallel thrust) without changing positions; **Dribble** Dribbling; **Pivot pass** Pass to the pivot; **Long pass Passing** with one or more positions omitted; **Sky** Volley Shot

Figure 1 and 2 pie charts were created for the better visualization of the differences.



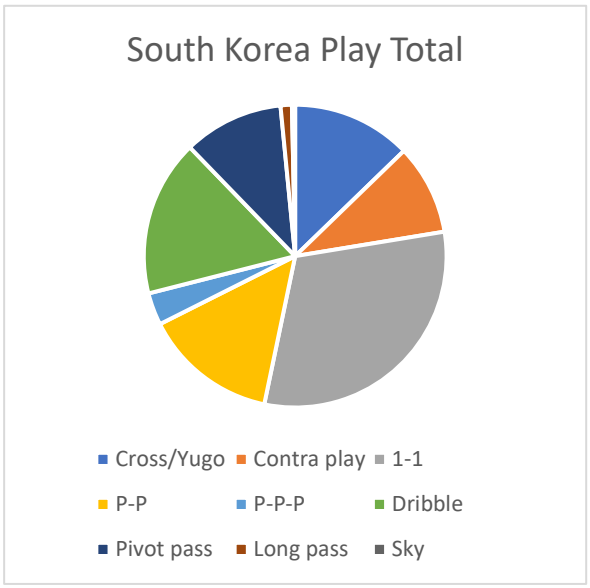


Figure 1. Ratio of qualitative indicators

Figure 2. Ratio of qualitative indicators

We ran χ-square test to clarify the relation between the differences of the indicators and created this mosaic plot (figure 3) for easier understanding.

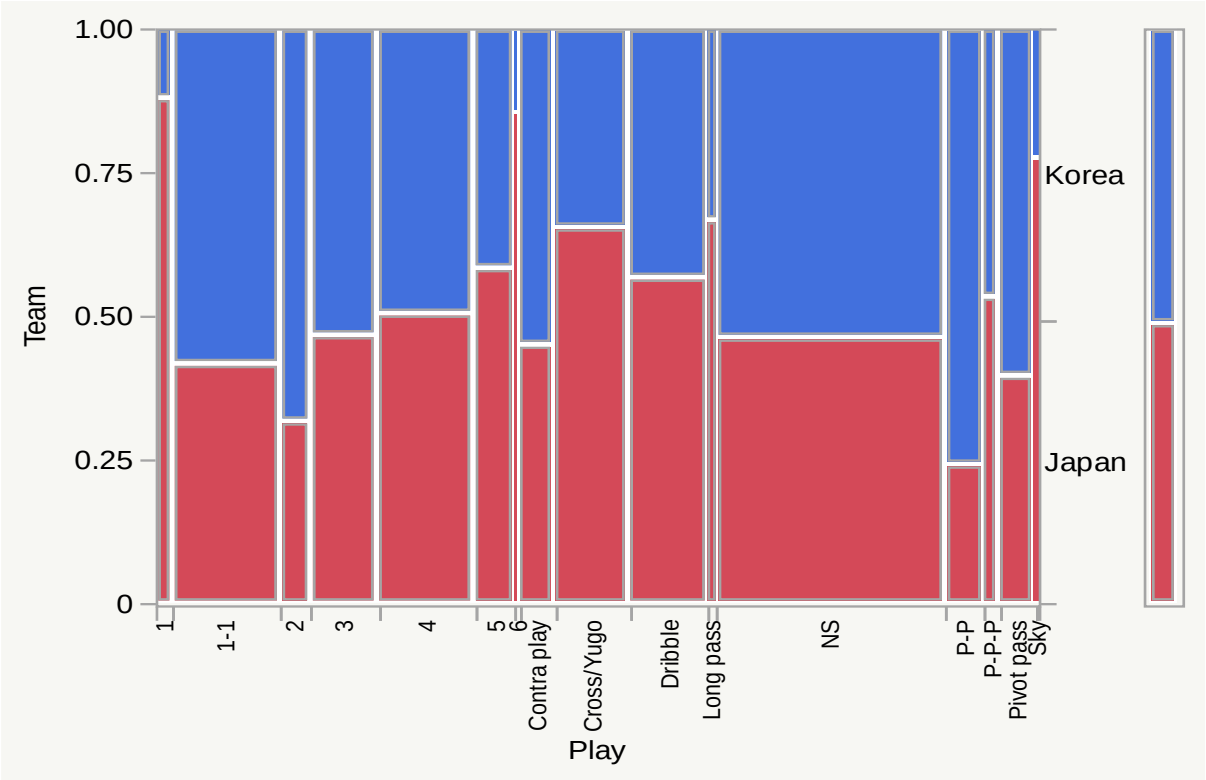


Figure 3. Analysis for Play and Team contingency mosaic plot

Finally, descriptive statistics in table 4 are showing the total number of fast counter attacks and their rate of success.

Table 4. Fast break success rate (H4)

Year	2019		2021		Total	
G/S	Goal/Attack	%	Goal/Attack	%	Goal/Attack	%
Japan	33/39	85%	20/26	77%	53/65	82%
South Korea	20/26	82%	11/21	52%	34/49	69%

Discussion

The results proved most of our hypotheses, except the one regarding the number of fast breaks and their success rate. The South Korean team organized attacks average length was significantly longer than the Japanese. However, both teams use more time than 33.3 seconds, which was found average on the 2017 Men's World Championship. The first hypothesis was correct, and we learned that the lengths of the organized attacks is not an indicator of their speedy image. Both teams were trying to build up the attack finishing phase mainly with 3-4 players cooperation. Hence our hypothesis was not correct, we could not find real difference in the number of players, but we could find significant difference in the way they were aiming to create chances in the finishing

phase of the organized attacks. The findings show that the South Korean team has been utilizing feinting in various positions and distances, contra play, cooperation with the pivot and 2 or more lateral passes without changing positions much more frequently than the Japanese team. They were typically changing rhythm and adding speed by quick contra movements or passes and continue with parallel passes to the other side. Japan on the other hand was trying to move the defenders with frequent position changes and direct passes to a farther position (e.g., left back to right wing). These findings had proved our third hypothesis was right.
Lastly, the data we found on fast breaks did surprise us a little. We hypnotized that both national teams use fast counterattacks in the same degree (occurrence) and success rate(H4). Well, the Japanese team has led 25% more fast breaks with a 36% higher success rate than the South Korean team. Thus, our fourth hypothesis had been proven wrong.

Conclusion

Understandably there are large number of studies of performance indicators that are related to win or lose. This study had not aim for that, rather a view on playing strategy or philosophy. As it happens with qualitative analysis, it is always difficult to create an objective system of criteria. Further studies are needed in order to find variables for being able objectively describe playing styles, playing philosophies.

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THE WAY WE SEE HANDBALL

How are the rules and the adaptation of the game shaping a more dynamic Handball?

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Summary

The purpose of this paper is to explore the way we currently see handball. A more dynamic game is shaped by the IHF rules and from the adaptation of the game. Defensive and attacking principles are influenced by new approaches and paradigms. In this scenario coaching philosophy, strategy, and tactic are important to find the synergic mix of all elements: physical, technical, psychological, and technological, that could give the opportunity to create a winning team.

Keywords

Handball coaching philosophy, IHF rules, dynamic system's approach, defensive and attacking principles.

Introduction

The Handball's game is a continuous evolutionary process since the origin, and in the last thirty years several changes have occurred in the rules of the game with the goals to increase attractivity, speed, and fair game from one side and reducing interruptions, violent actions, and passive play from the other one. These changes are influencing the way to see handball, and are improving the technical, tactical, and strategic approach of the game. Other changes are also planned in the next few years to avoid simulation and faking fouls to increase a fair game.

All these changes and the consequent evolution of the game are increasing the requirements for the coaches to adapt their philosophy to this scenario in defense and attack. Many top coaches are also calling for innovating the way we are coaching and training,

> "In order to make progress and to have future excellent and creative handball players, we must change the technology, i.e., the methodical-didactic approach in our daily training. Those are the changes" (Cervar, 2015, p. 2)

Nowadays handball defensive and attacking systems are changing. Players adapt their movement to the attack and vice-versa. From a well-defined set-defense 6-0, we are reaching a very dynamic game in attack and in defense, where collaboration, adaptation, and anticipation are the major principles for a faster game. Therefore, it is necessary to identify the possibilities of changes in the dynamics and strategic understanding of the handball game. It could also be useful to discuss the possible reorganizations of the individual and group tactical actions, the offensive, and defensive systems, by coaches and other stakeholders.

Methods

A qualitative research approach was adopted to search for elements on articles, speeches, interviews, books, and videos available of elite handball coaches and experts to study the coaching phenomenon, using an inductive method of analysis. The qualitative methods approach gives the opportunity to generalize from the observation of specific examples, and content analysis is a good way to highlight knowledge through the coach's discourses and experience. The reason for collecting information from scholars' articles and elite coaches' speeches is also justified by their ability to analyze the game and team performance's efficiency, and to identify possible changes in the dynamics of the game for validating and developing some general conclusions.

Framework

This paper explores coaching team handball using the framework of the dynamics-systems theory to analyze the defensive and attacking principles in relationship with the team opponent. The reason to use the dynamics-systems theory as theoretical framework is based on the dynamics of the game and on the balance of power between teams (rapports de forces from the "francophone school", Gréhaigne, J.-F., & Godbout, P., 2012).

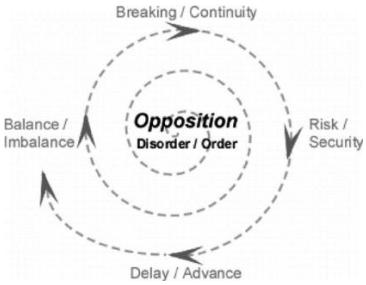

Figure 6 - Rapports de forces (Opposition - Balance of power)
Source: Gréhaigne, J.-F., & Godbout, P. (2012) Dynamic Systems Theory and Team Sport Coaching, 96–156.

Following this theory, the teams involved in a game are considered: "as two interacting systems in movement, where opposition is paramount. A key element for the observation of gameplay is the notion of configuration of play and its ever-changing shape, namely through phases of contraction and expansion, and it's moving location on the court".

Development

Philosophy of the game

Defensive Principles

The innovation on the rules of the game has changed the way we see handball nowadays. From a traditional defensive game (6-0), based on tall and strong defenders, especially in the center of defense, we moved to more dynamic defensive systems (5:1; 4:2; 3:2:1, etc.) where "mobility and anticipation" (Román Seco J. D., 2016, p. 153) are the new characteristics of the defense.

The new rules have changed the dynamic principle of “rapports de forces” (balance of power) between attackers and defenders, “creating a continuous process of adaptation of the attack to the defense and vice-versa”. (Cervar, 2015)

In this scenario, the defensive systems require a more creative and dynamic approach where space, timing, and anticipation of the attack are preferred to the previous principle of action-reaction. Individual and collective defensive skills are extremely important as well as in attack. Aggressive mindset in defense is necessary to recover the ball and read the individual and collective movement of the opponent.

The role of the defender is enriched today from several functions that are not only to block the opposition or avoid scores. Players then should understand and practice the strategic function of the defense. Understanding and visualizing the game with the same glasses as the coach to have the same vision of the game.

The application of the defensive principles is constantly challenged from the attack. During the game, the attacking team (opposition) will try to continuously create new situations to unbalance the defense and score. Strategic and tactical preparation is important, but the coach needs to consider that the application of fixed defensive movements (tactics) could be the limit of the defensive system by itself, especially against creative and fast attacks.

The coach needs to help the team to overcome these situations building confidence and collaboration on recovery of the mistakes. Teamwork and collaboration are the best way to answer the dynamics of the attack and recover unbalanced situations and mistakes. In this case we can talk about “balance of power” and every defensive activity depends on the ability to anticipate the attacker´s action on time or quickly recover the mistakes. The situation’s principle requires that players who are in the trajectory of the ball become responsible for the attacker to anticipate or to avoid the shot. The other players have the task to help and recover eventual mistakes. At the same time, we need to be aware that the team in attack knows that every time when there is a “helping” situation in the defense there are more opportunities to score in another zone of the court.

The defensive action should be continuous. Furthermore, defenders need to understand the dynamics of the attack and their game to anticipate and intervene simultaneously on the attacker and prevent the pass, the blocking, or the penetration with or without the ball.

Anticipation is the key for solving situations of disadvantage. Although, anticipation alone will not be enough, and sometimes even dangerous if this is not coordinated with the rest of the team or performed too late. Also, anticipation is different from pressure:” for example by deterring passing or exiting a situation of possible blockage, deterring the attacker's intent by creating density and using arm movement, or making it difficult to attack procedures with defensive fakes”. Garcia Herrero highlights this idea in the past pointing out different possibilities for action in defensive anticipation (Garcia Herrero, 2003, p. 201).

Other authors said that defenders must cause uncertainty on the contrary of distorting intentions, hiding, or changing them. “Individual training in open situations is therefore required, and the team is equipped with more than a possibility of resolving the same situation. A defensive system must be sufficiently flexible without cluttering” (Avila Moreno, 2015, p. 150). In defense, the concept of not defining ourselves if it is not preventing a clear reading of the attack. The defense, individually and collectively, needs to maintain a constant dynamism. Laguna (2005 pp.12-13) concludes his article by stating that in defense, "the evolution of the defensive systems come from ambiguity," a "calculated ambiguity" (Avila Moreno, 2015, p. 150).

The evolution of the defensive game requires a more physical, technical, and tactical preparation than in the past, at both, an individual and collective level. Individual defensive training should be focused on acquiring skills that could help to reach the previous defensive objectives with more creativity and flexibility following the major principles of anticipation and continuous mobility.

Attacking Principles

The changing in the philosophy of the defense, and the consequent development of new defensive systems, created the need for new paradigms and approaches in attack.
Over the course of several years, attack and defense are continuously modifying each other and the way we see contemporary handball. The transition from one defensive system to another is, most of the time, a tactical decision to overcome the attacking system and vice-versa. This dynamic model can be analyzed as a power of balance (Figure 1: Rapports de force) between the two functions of the teams during the game.

The major tactical objectives of the attack are to occupy the maximum space and constantly mobilize the defense using several collective solutions like penetration, combination, changing rhythm, faking, ball circulation, crossing and other technical and tactical means to defeat the defense.

The principles of attack help a team in possession of the ball to react to any situation during the game. These basic principles of attack may apply when a team is looking to keep possession of the ball, move the ball forward into an attacking position and create chances to score a goal.
The activity of the players during the game is based on the tactical principles in attack as well as in defense. Their physical, technical, and tactical abilities determine the execution of the strategy and the level of their performances. The different level of preparation, knowledge and skills underline the level of the individual and collective activity. In contemporary handball, the individual activity is related in a synergic way with all the other players of the team and the collaboration with and without the ball are extremely important to create attacking opportunities.

Analysis of the players

Handball roles and positions are changing in nowadays game. It is no longer a fixed position that identifies the characteristics of the players, but more and more the different functions and the synergic tasks that the handball players perform during the game.

Goalkeeper

The goalkeeper´s mindset, focus, and leadership are particularly important in Handball. Leading the defense, with the ability to read the game, the playing, and the shooters, are just a few of the important things that goalkeepers need to do besides the most important that is saving the ball. Intelligence, cleverness, and the ability to stay focused are some of the skills that we need to evaluate when we recruit and train a goalkeeper. During the IHF Coaches 2017 Symposium in France, Mats Olsson said:

> “If you look at the goalkeepers today, the top level of the world, one of the biggest differences between the top goalkeepers, both men's and women's, is the focus when you're

playing. How focused you could be on the game. How focused you can be under the ball, and you can anticipate what will happen…" (Olsson, 2017)

The goalkeeper should be able to read the game and needs to be prepared as well as any other player following the tactical sessions, and depending on the coach's preferences, could be a useful resource to set up the defense promptly.

Decision making, timing, and individual tactic is important as well as technique. Therefore, their training should be focused not only on physical work and technique, but in reading the game, the shots, and the several ways to avoid the goal. Then, the role of the goalkeeper requires a coaching plan and analysis to learn, and practice in how to react in different situations. The focus is no longer on the technique but in reading the game. Every goalkeeper needs to develop his own mindset, instinct, and a way to understand the situations:

> "We work the physical part, but we do not work a lot with the tactical one……. as goalkeeper coach …it's less talking about the techniques. We have passed that way, but we have more in the mind and mental aspect of the brain of helping the goalkeeper to read his shot that really keeps him in the game." (Olsson, 2017)

To this day, the level of the shooters has improved and therefore we can see from the statistics that goalkeeper's savings are reducing from the past in International competition (Olsson, 2017). The changing rules and the application of the progressive punishment for a fair play are also changing the way the defense approaches the game as well. The defender must not hold or push too much as in the past because of the application of the progressive punishment; and this is changing even the training of the individual defense (1vs1) in many countries. The attack was also improving the quality of the shooting, from one side because the major opportunity to shoot and from the other side the improvement in the individual technique:

> "Looking at the games I can see especially two things……Today, we have the wing players that always try to make it last change with the fingers, and now I can see also the back players are using more and more shoulder, elbow hand and fingers and making new twist the ball and the last moment it makes it more complicated for goalkeepers" (Olsson, 2017)

Goalkeeping is extremely important, and we need to give this role the right attention in terms of training, time, and sources.

Players

The ability to read the game and understand quickly the different situations could be extended at any position in defense and attack. Anticipation mindset, adaptation, and collaboration are vital. Individual and group defensive and attacking skills are under revision because the need of a fair and less violent game. The changes in the IHF rules about the punishments in defense (reduce aggressive and violent defense, avoid provocations and simulation) and the quality improvements of the attackers are modifying the way defenders are approaching the game. The players need to change their mindset to use the fouls all the time to stop the attack and need to improve their individual performances if they want to win within the new scenario (Román Seco J. D., 2016, p. 6).

Coaches must rethink and adapt their approach to the game within the new rules with players physically, psychological, and technically well prepared able to use timing and space in a perfect way. The old approach of the individual defense, even if it is still valid, needs to be changed for a more creative defense if you want to stay in the game. Many countries have already changed the way to develop individual and collective skills. For example, instead of looking for the arm to block, the attention now is more focused on the ball and body control by means of the arms forward position. Timing and space are now more important for the defender because they are not able to close the attacker or the gap easily with a non-permitted foul anymore because this can increase the risk to get a progressive punishment than in the past. This already leads the way how defenders will be prepared and will bring a compromise between strength and speed.

> "Handball has taken an evolution or a leap in its physical aspect or dimension. Now the players are denser and faster than the past" (Dinart, 2017).

Today, we see that players are not only stronger, but the dynamism of the game requires that they must be even faster than in the past. This is leading the way how the coach will recruit athletes and train them. Under the new scenario the players need to continuously improve their individual and collective technique. Individual defensive skills are related to individual and group defensive tactics. Nowadays the ideal defender is one who, not only prevents the score but also understands the attack and the attackers and can collaborate with the other defenders to get the ball back. This mindset influences "the tactical intention and related structure of the defense" (Bayer, 1982, p. 96).

Mobility and collaboration are extremely important in both attack and defense. These characteristics require a solid physical and technical preparation to be competitive and apply defensive and attacking principles. Attackers are usually the most skilled athletes, but individual skills are not enough in handball. We need players who collaborate with each other and can make quick decisions in any condition.

Conclusion

Since the origins of Handball, the philosophy and rules of the game have changed several times. Over the past thirty years, several changes have "shaped" a more dynamic game, both in defense and attack, with the aim of increasing attractiveness, speed, and fair play.

The purpose of this study was to explore how these changes affected coaching and the way we see contemporary handball. Using a qualitative method, we focused our attention on the change in the contemporary philosophy of the game and in the evolution of defensive and attack systems. In this scenario, defensive systems require a more creative and dynamic approach in which space, timing, and anticipation of the attack are preferred to the previous reaction-action principle. In addition, individual and collective skills are extremely important in defense and in attack.

The aggressive mindset is necessary for quick recovery of the ball and read the individual and collective movement of the opponent. Anticipation and mobility are the keys for solving disadvantageous situations. The different levels of preparation, knowledge and skill underline the level of individual and collective activity. The increase in player level and the demand for attractiveness required by contemporary handball, is increasing at the same time as the level of complexity and efficiency of the game systems.

In contemporary handball, individual activity is synergistically related to all other players on the team and is extremely important to create new attack opportunities. Mobility and collaboration are both vital in attack and in defense. The evolution of the game therefore requires greater physical, technical, and tactical preparation than in the past, both individually and collectively. Therefore, today we need more technical and dynamic players, with excellent individual and collective skills who can read the game and quickly make the best decision. One of the major goals of the coach is to help players, with knowledge and skills, to recognize situations and adapt their decisions in function of the context of the matches.

Further studies could investigate how coaches are rethinking and adapting their training approach to the game within the new rules and in the application of the new philosophy of the game.

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TEAM HANDBALL AND EMPTY GOAL (7VS6) RULE – THE COACHES PERCEPTION

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Summary

The introduction of new rules in Handball has been a constant in the last two decades. However, few rules were as controversial as the rule that allows the change of a goalkeeper for a field player (Empty goal) allowing teams to play 7 vs 6. With this study we intend to evaluate the perception of coaches from several countries about the rule that allows them to play 7 vs 6 without goalkeeper. The results show that 76% of the coaches agree with the possibility of playing 7 vs 6.

Keywords

Handball, 7 vs 6, Empty Goal ,Coaches, Perception.

Introduction

The introduction of changes or new rules in Handball has been a constant in the last two decades. This aspect arises to make the game faster, spectacular and increasing intensity.

However, few rules were as controversial and not consensual as the rule that allows the change of a goalkeeper for a field player (Empty goal) allowing teams to play 7 vs 6. This rule has been contested and caused some division between the coaches opinions, despite being an increasingly frequent practice. In the last major competitions, there has been an increase of the use of this tactical-strategical option leading to some investigations and studies about this topic (Krahenbühl, Sousa, Leonardo, Galatti, & Costa, 2019; Korte & Lames, 2019; Gümüş, Sahinib, & Gencoglu, 2020; Maroja, Silva, Oliveira, & Filho, 2020; Spate, 2019, 2020)**.**

We think it is important to continue to evaluate the implication of these rule and the way coaches see and use it in order to reduce the lack of studies on it.

With this study we intend to evaluate the perception of coaches from several countries about the rule that allows them to play 7 vs 6 without goalkeeper.

Methods

In order to evaluate handball changes, nothing is better than all major competitions such as the Olympic Games, the World and European Championship. In a previous study Prudente, Cardoso, Rodrigues and Sousa (2019) registered only 19 attacks with empty goal, a number considered poor

by them. The increase was notorious since that competition. Considering that, we tried to understand how coaches manage that rule.
The sample included 125 coaches (10 women and 115 men), aged between 21 and 69 years old (43.01±11.74), from different continents such as European (n=104), Southern American (n=14), African (n=6) and Asian (n=1).
To collect the data, a questionnaire was used, duly constructed, and validated by 17 experts through a questionnaire, with a 5-point Likert scale (from 1-I Totally Disagree to 5-I Totally Agree) and to validate the categories, a cut-off value of 75% of agreements was considered. All coaches had at least 10 years of experience. The questionnaire had 41 questions divided by two topics: characterization of coaches and coaches 7 vs 6 opinion. The final questionnaire was applied through google forms. We analyzed data using simple and descriptive statistics.

Development
With this study it was our intention to evaluate the perception of coaches about the rule that allows them to play 7 vs 6 without goalkeeper.
Our first big question was about the possibility of playing 7 vs 6 (Figure 1). After the division of coaches opinion about this, we can see that 76% of the coaches agree with that possibility. On the other hand 24% did not agree with that option. 3 out of 4 coaches of our sample were in favor of the new rule.

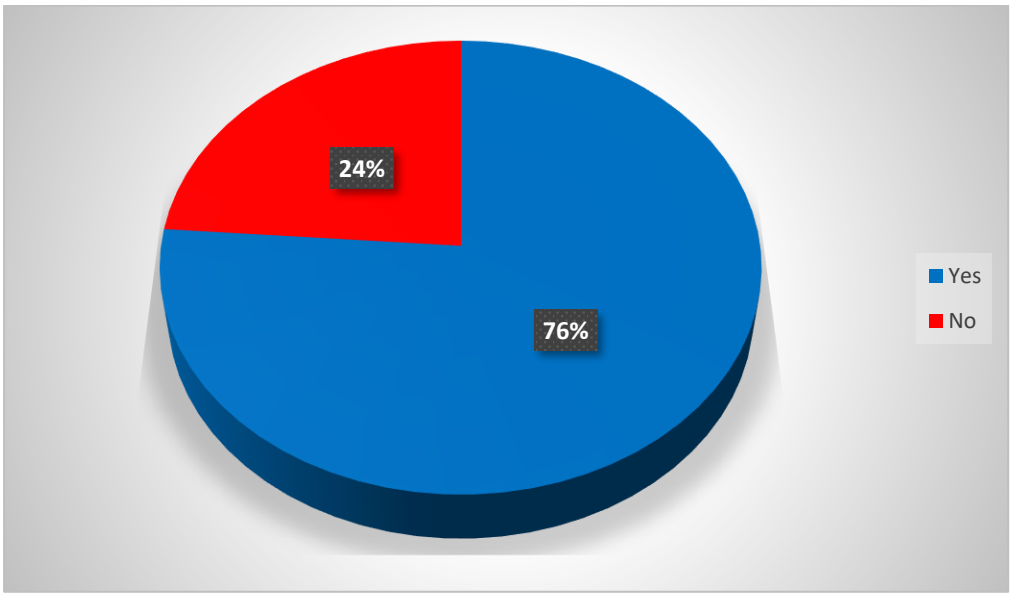

Figure 1 – Do you agree with the possibility of playing 7 vs 6?

Figure 2 shows the coaches answers about the handball game being out of character with the introduction of the rule that allows teams to play with empty goal.
This figure shows that almost 60% of the coaches do not consider that possibility. In other words, the opinion of the coaches who called for the game to be de-characterized is not confirmed in our sample.

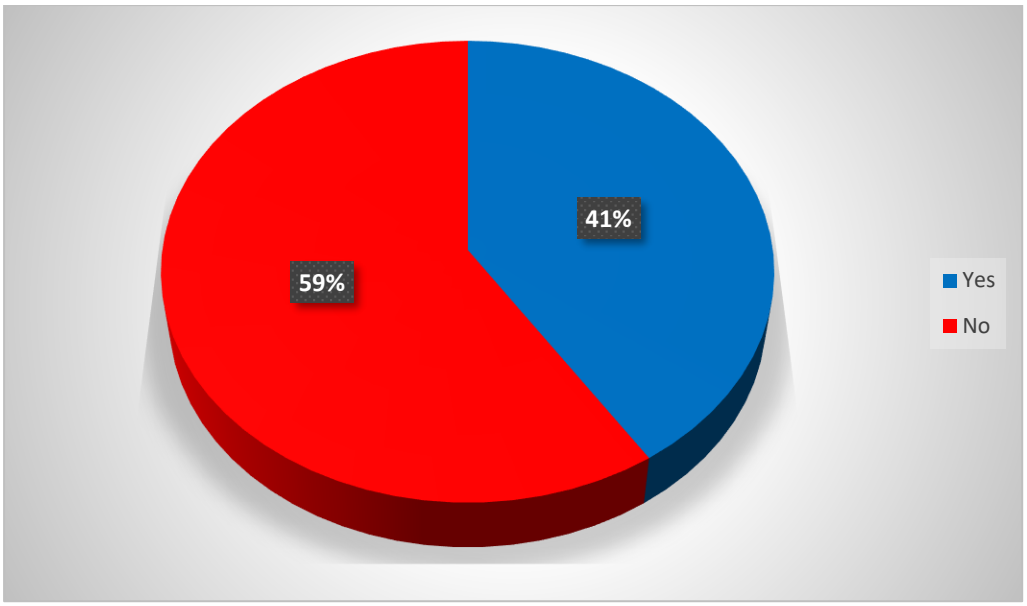

Figure 2 - Do you think the handball game was out of character with the new rule that allows to play 7 vs 6?

When we asked coaches about the introduction of the 7 vs 6 being the natural evolution of the game, answers were not consensual. Results shows that some coaches Agree (31%) or Totally Agree (10%) contrary the ones who Disagree (17%) or Totally Disagree (16%). In this Figure 3 we can verify that 26% of the coaches Do not Agree nor Disagree (26%).

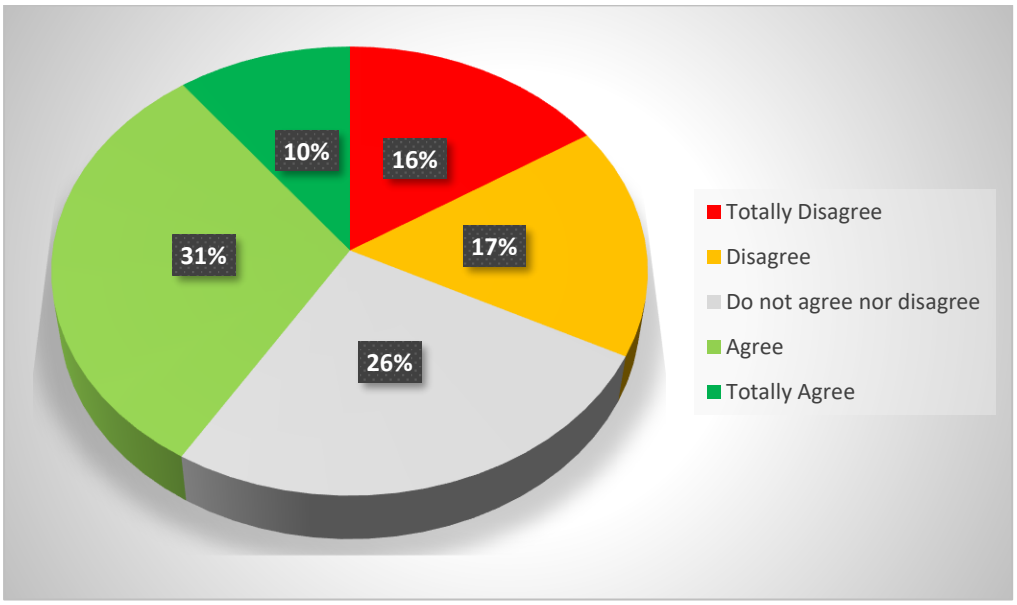

Figure 3 - The introduction of the 7 vs 6 game situation was the natural evolution of the game.

We asked the coaches if they were in favor of changing the rule that allows teams to play 7 vs 6 as it is today (Figure 4).
It was curious that 58% of coaches agreed with that, contrary to those 42% that agreed to maintain the rule as it is today. We can suppose that some coaches agree with the rule but would change some part of it.

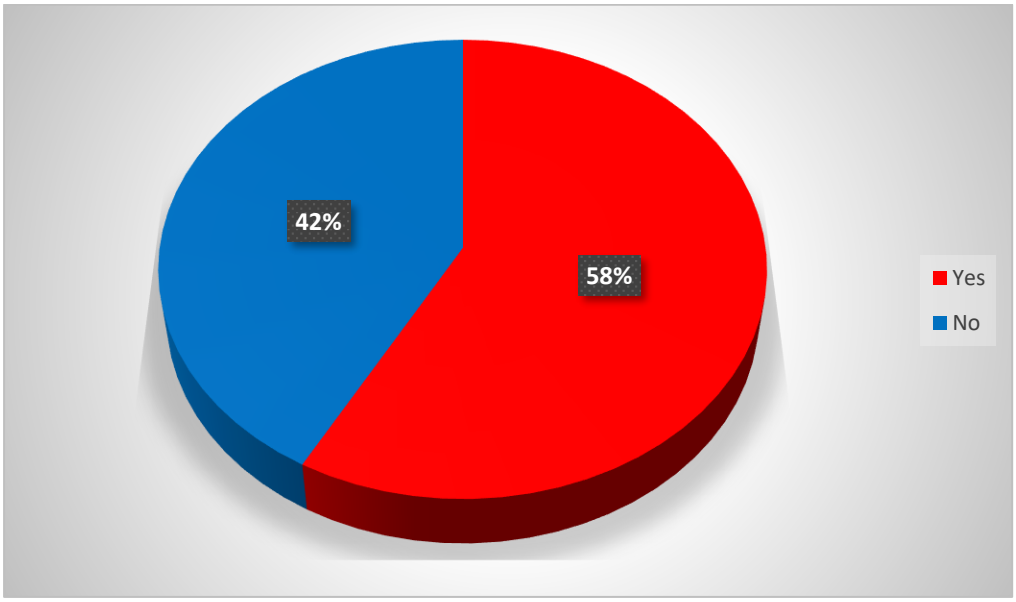

Figure 4 - Are you in favor of changing the rule that allows the 7 vs 6 game as it is today?

One of the most important questions was the one in Figure 5. We asked coaches “Are you in favor of this rule abolishing?” and the larger part were not in favor about the abolishment of the rule. Although 34% agreed with the abolition of the rule, 66% disagreed with this possibility.

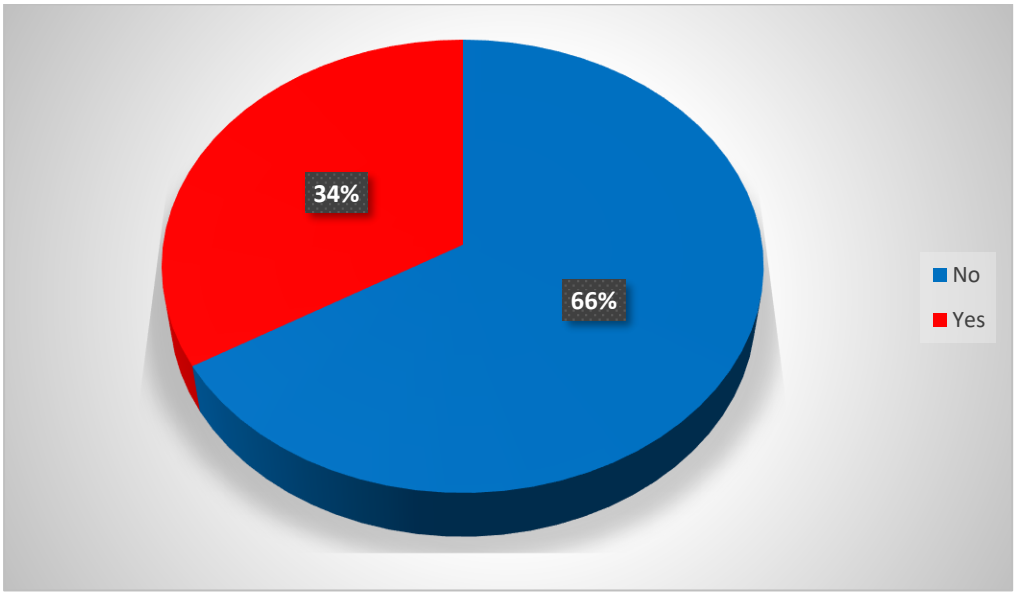

Figure 5 - Are you in favor of this rule abolishing?

Analyzing the results, we can say that: i) 76% of the coaches agree with the possibility of playing 7 vs 6; ii) 41% indicates that the game was uncharacterized; iii) 40.8% say that the introduction of

7 vs 6 is a natural evolution of the game; iv) Although 33.9% are in favor of the rule that allows play 7 vs 6 being abolished, 66% are against it, just as the majority (58%) are in favor of changing the rule without abolishing it.

Conclusions

These results give another reflection on the coaches perception about the rule that allows teams to play 7 vs 6. We strongly believe further studies are needed to understand what changes this rule caused in the game and in the behavior of teams, players and coaches, and verify if it is more used by coaches. Increasing the sample and observing more competitions is recommended.

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ASSESSMENT OF THE EQUALITY OF WOMEN'S HANDBALL MATCHES IN TOKYO 2020 ACCORDING TO THE RELATIONSHIP BETWEEN RESULT AND PLAYING TIME

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Summary
The competitive level at Female Tokyo 2020 is expected to be very high. The evaluation of the evolution of the score throughout the playing time allows establishing the critical moments of the match and analyzing the competitive equality of the tournament. Results showed that 58% of the games were very balanced or balanced. Winners presented better throwing indicators at critical moments.

Keywords: dynamic time warping; balanced games; critical moments; offensive indicators; winners and losers.

Introduction

The study of different factors that affect the development of the game of handball has been studied from various approaches within different elite competitions (Saavedra, 2018). Static or dynamic approach has been used indistinctly in order to analyse the performance in team sports (Prieto et al., 2015). The dynamic approach analyses the data not only limited to a descriptive level, but also seeking to understand the context where the actions are developed for example during the time line of a match. It is, in this type of studies that among other indicators such as scoring efficiency, critical moments or the discriminating variables between winners and losers are present.

Currently, this approach is very present in the different investigations within elite handball. For example, Lozano, Camerino & Hileno (2016) analysed through the detection of temporal patterns (*T-patterns*) the variables that influence the offensive phases, taking into account different elements of the competition. The use of polar coordinates exposes the relationships in the finalizations of winners and losers (González et al., 2013) or the tactical behavior patterns of the players according to the numerical relationship on the court (Prudente et al, 2019). The coordination of the match status during games has been studied using temporal series (Lames, 2006; Prieto et al., 2016).

On the other hand, some studies have classified the games depending on the final score in order to analyse the even competitive situations. In this sense Botejara et al. (2012) considered as balanced games those were the final score difference was no more than 3 goals. Meanwhile Prieto et al. (2016) used a cluster analysis and grouped the games of the spanish handball league with a

maximum difference of 5 goals in the score and Paula et al. (2020) with a maximum difference of 8 goals in female handball.

Olympic Games (OG) are an important competition stage where sport performance has been studied in the last years (Krahenbühl et al., 2016; Montoya, Moras & Anguera, 2013; Trejo- Silva, Gómez-Ruano & Brazo Sayavera, 2020). The competitive level is expected to be very high at Tokyo 2020 OG. Following this assumption, the aims of this research were to catalogue the games according to their level of equality in the final score and to analyse the offensive performance of winner and loser for each stablished group.

Methodology

Sample was composed by the 38 matches of the female competition at Tokyo 2020. Data was collected from the "Play by Play" sheet available at the official web site. A total of 4972 finishing actions were registered.

For the statistical treatment of the data, the measures of central tendency, mean and standard deviation were used. The groups were compared using the nonparametric Wilcoxon test. In all cases, values with $p < 0.05$ were taken as significant. Chi-square test was performed to analyse the correlation between variables.

The clustering of the matches was carried out using the dynamic time warping (dtw) algorithm that allows comparing time series (Giorgino, 2009). This technique measures the similarity between two time sequences that do not line up exactly in time, speed, or longitude. In this case, the time series of each game established by the difference in the score over the playing time were compared. Processing was done using R.

Results

Clustering using time series analysis of the difference in score between teams over time generated four groupings of matches (Figure 1): unbalanced matches, poorly balanced matches, balanced matches, and very balanced matches.

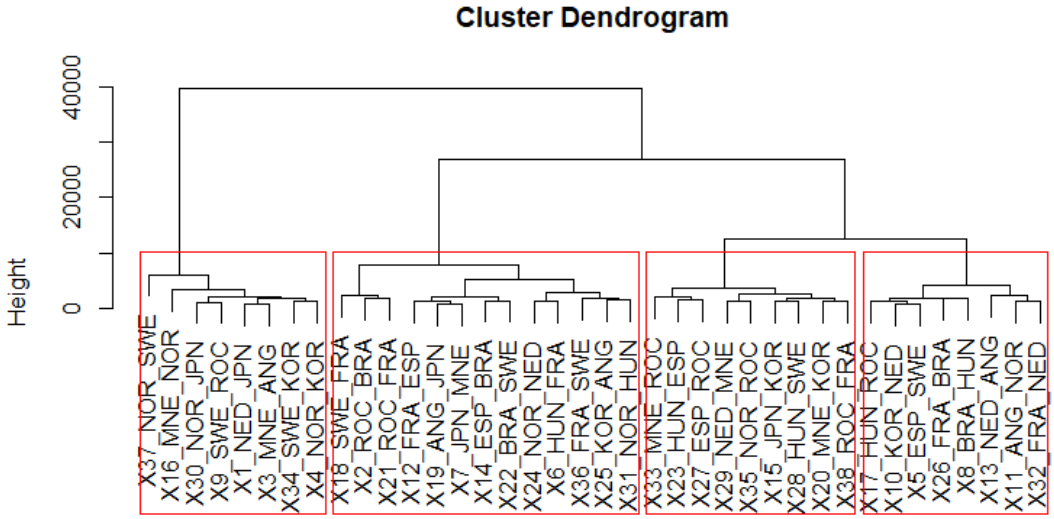

Figure 1. Match classification dendrogram according to the evolution of the result over time. From left to right: unbalanced, very balanced, balanced and poorly unbalanced matches.

Figures 2 to 5 show the behaviour of the scoreboard throughout the playing time for each of the four clusters of matches.

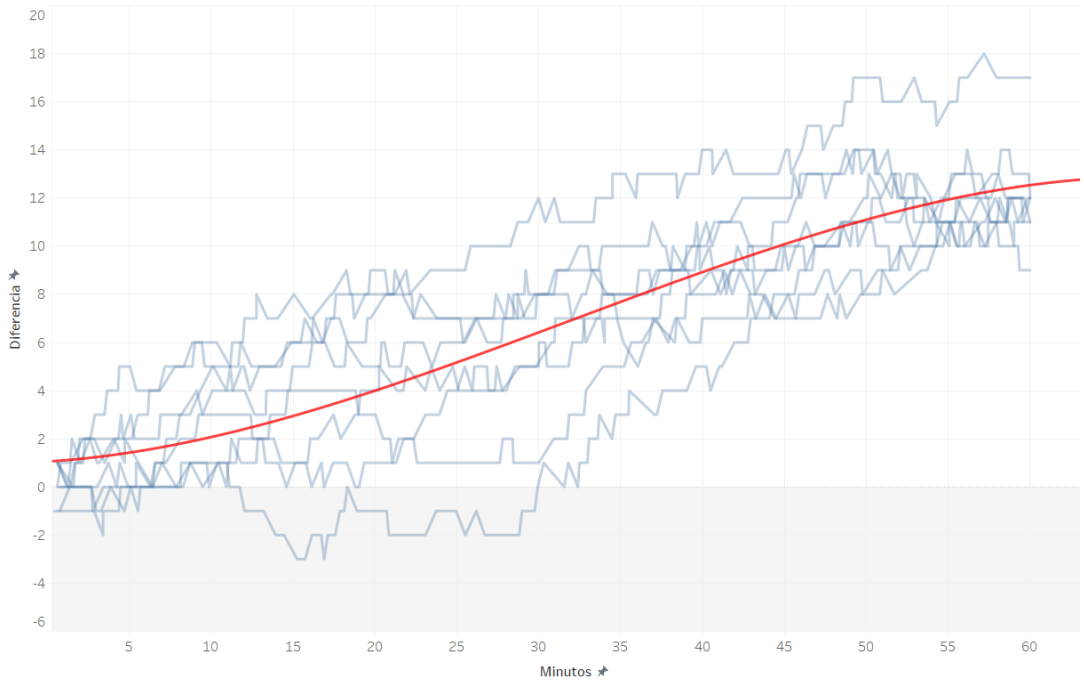

Figure 2. Evolution of the difference in the score between winning and losing teams in unbalanced matches.

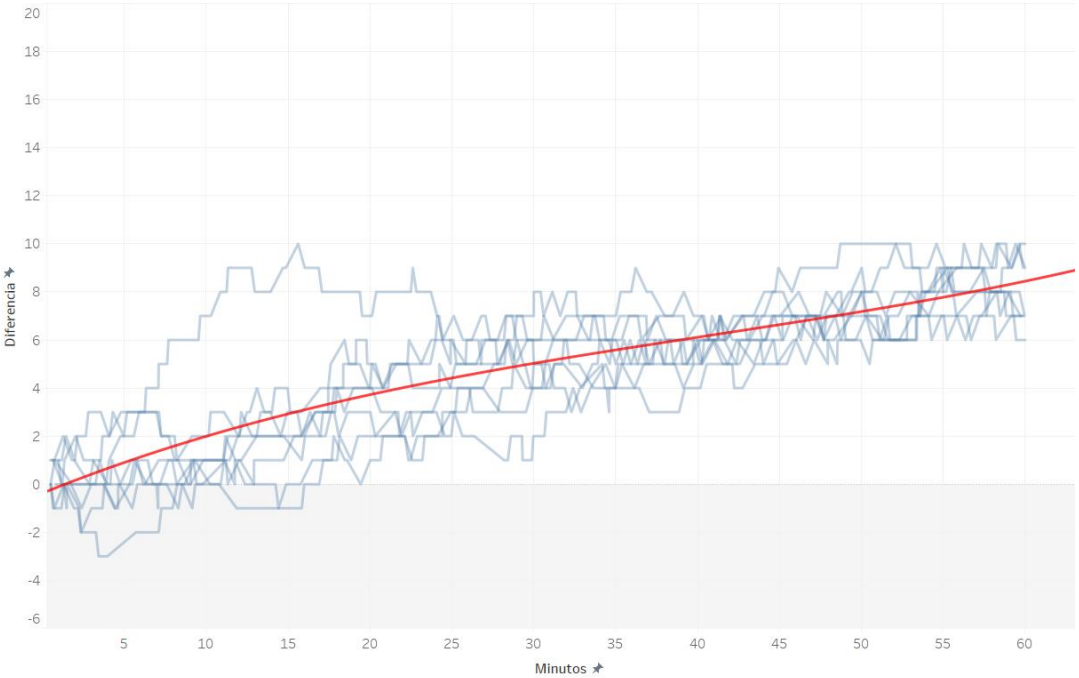

Figure 3. Evolution of the difference in the score between winning and losing teams in poorly balanced matches.

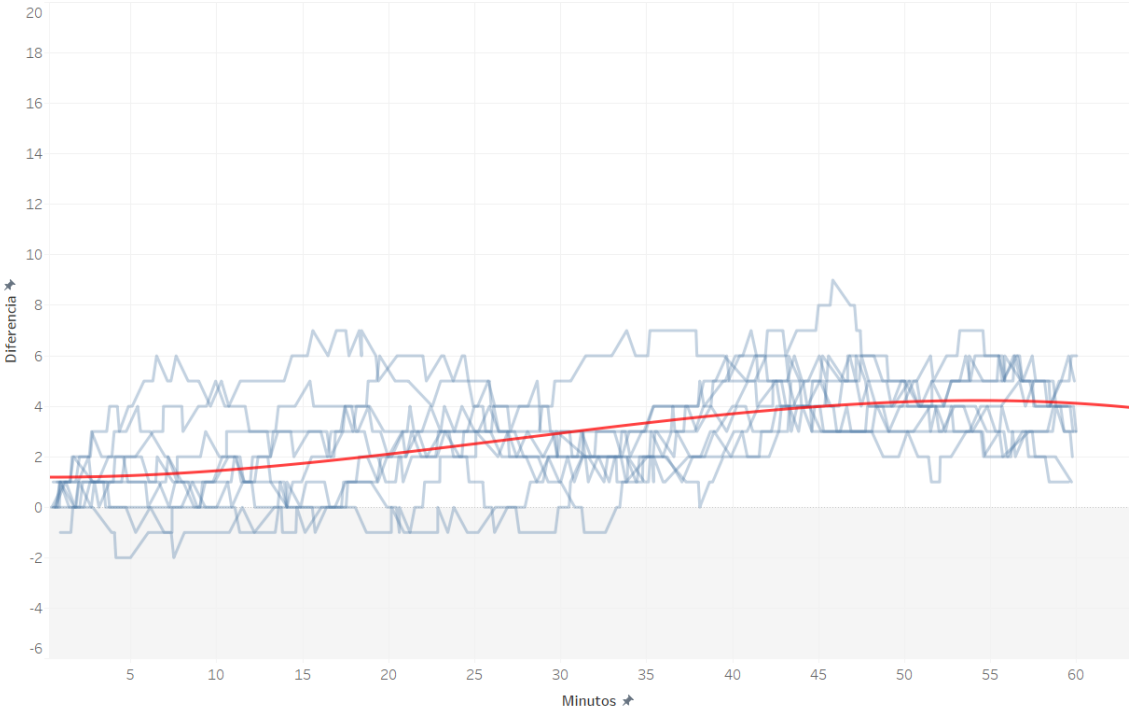

Figure 4. Evolution of the difference in the score between winning and losing teams in balanced matches.

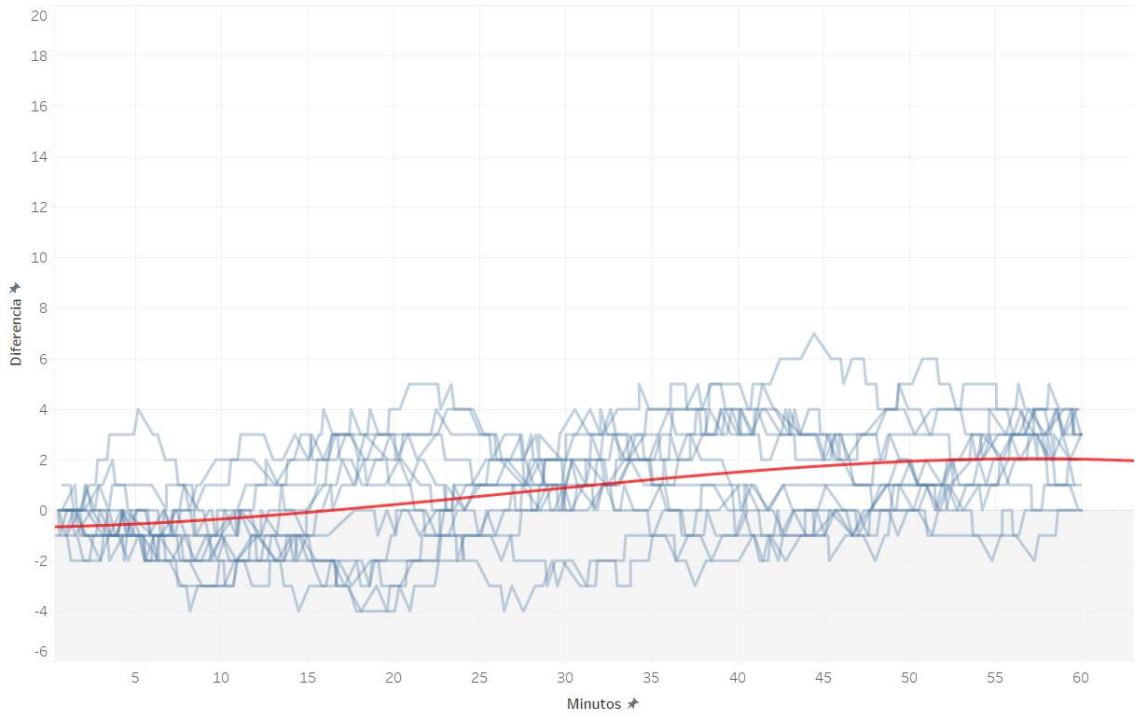

Figure 5. Evolution of the difference in the score between winning and losing teams in very balanced matches

The evolution of each match separately can be found in https://public.tableau.com/views/LineadetiempoHandballFemeninoJJOO2020/Dashboard1?:language=es-ES&:display_count=n&:origin=viz_share_link
The distribution of the matches in the tournament phases showed that 57% of the matches in the first phase were balanced or very balanced, as were the semifinals and the final. In contrast, two quarterfinal matches and the match for the bronze medal were unbalanced or poorly balanced.

In the very balanced and balanced games, the Chi-square test showed that there was no significant association between finalization in goals and the condition of winners and losers. However, shots that ended in saves by the goalkeeper´s opposite teams did present a statistical significant relationship ($p < 0.01$) having the winners less saved shots than losers (Table 1).

Table 1. Distribution of the efficacy of the finalization actions of winner and loser within the clusters referred to very balanced and balanced games.

Cluster	**Winner/loser**	**Goal**	**7m**	**2 Min**	**Saved**	**No goal**	**Techincal fault**	**Bad handling**
Very balanced	Winner	45,8%	8,1%	4,3%	13,5% *	7,2%	7,3%	13,8%
	Loser	40,2%	8,3%	5,1%	19,2% *	8,0%	6,7%	12,5%
	Draw	42,8%	7,2%	5,4%	14,4%	9,6%	5,9%	14,7%
Balanced	Winner	45,0%	6,8%	4,5%	18,0%	7,7%	7,0%	11,0%

Loser	40,1%	6,8%	6,0%	17,1%	7,7%	8,0%	14,3%

(*) shows the significant differences between winners and losers with p <0.01 in the adjusted residuals test.

Regarding the playing period, in the very balanced matches the Wilcoxon test showed significant differences in the number of goals scored between winners and losers in the minute 26 to 30. In the case of balanced matches, no differences appeared in any of the periods of play (Table 2).

Table 1. Mean and standard deviation of the goals scored by the winning and losing teams in the different time periods according to the different groupings of matches.

	Very balanced		**Balanced**	
Period	**Winners**	**Losers**	**Winners**	**Losers**
1'-5'	1.8 ± 1.2	2.2 ± 1.0	2.8 ± 1.5	1.7 ± 0.9
6'-10'	2.1 ± 1.2	2.8 ± 0.8	2.3 ± 1.2	2.0 ± 1.1
11'-15'	2.6 ± 0.7	1.7 ± 1.6	2.3 ± 1.0	2.1 ± 0.6
16'-20'	2.4 ± 1.2	2.4 ± 1.1	2.7 ± 1.7	2.2 ± 1.0
21'-25'	2.5 ± 1.2	2.0 ± 1.5	2.8 ± 1.0	2.3 ± 1.1
26'-30'	2.8 ± 1.0*	1.9 ± 1.2*	2.0 ± 1.4	2.6 ± 1.3
31'35'	2.5 ± 1.1	1.9 ± 0.9	2.2 ± 1.0	1.8 ± 1.2
36'-40'	2.4 ± 1.1	2.0 ± 0.8	2.8 ± 1.3	1.6 ± 0.7
41'-45'	2.2 ± 1.1	2.4 ± 1.3	3.0 ± 1.1	2.1 ± 1.2
46'-50'	2.3 ± 1.2	2.1 ± 1.1	1.8 ± 1.1	2.6 ± 1.4
51'-55'	2.5 ± 1.1	1.9 ± 1.4	2.3 ± 1.2	2.1 ± 1.4
56'-60'	2.7 ± 0.9	2.9 ± 1.3	2.1 ± 0.6	3.1 ± 1.3
Total	2.4 ± 1,1	2.2 ± 1.2	2.4 ± 1.2	2.2 + 1.2

Significant differences are noted in the Wilcoxon test between winners and losers for a period with values p<0.05 (*).

Discussion

Olympic Games are the most important sporting event in handball where the best teams from each continent participate. The competitive level is expected to be very high. The evaluation of the evolution of the score throughout the playing time allows establishing the critical moments of the match and analyzing the competitive equality of the tournament. The aim of this study was to classify the matches according to their degree of equality in the final result and to analyse the offensive behavior of winners and losers for the established groups.

The grouping of time series was performed with the "dynamic time warping" algorithm. The result from the cluster analysis presented four types of matches: very balanced (13) 34%, balanced (9) 24%, poorly balanced (8) 21% and unbalanced (8) 21%. This classification allows to distinguish between the matches with more adjusted results than other groupings made previously (Prieto, Gómez & Sampaio, 2016; De Paula et al. (2020). In this case, the number of balanced and very

balanced matches seems adequate to the competitive level expected in the Olympics, although on the other hand, the unbalanced matches can be considered quite large.
In order to critical moments, in the very balanced games the number of goals obtained at the end of the first half presented a statistically significant difference between winners and losers ($p<0.05$); In addition, in the case of balanced matches, the advantages obtained by winners in periods 1'-5 'and 36'-40' were noticeable, although they did not reach significant differences. The importance of the initial and intermediate periods of play during the game have already been reported previously (Botejara et al., 2012; Rogulj et al., 2011). The advantages obtained were maintained throughout the final minutes of the match, where the losing teams cannot reverse the score.

Conclusions

The time line score of the clusters showed that women´s tournament at Tokyo 2020 was a competitive championship. Winners presented better throwing indicators at critical moments. The differences between winners and losers show moments of play that should require attention when evaluating performance.

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COMPARATIVE ANALYSIS OF THE GAME 6vs6 AND 7vs6 WITH EMPTY NET IN MALE ELITE HANDBALL AT EURO AND WORLD CHAMPIONSHIPS 2017-2020

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Summary

Since Rio 2016 it is allowed to change the goalkeeper for a field player, affecting the game during stationary attack and having an incidence in the concept of *numerical equality*. It appears to be relevant to study the offensive performance in both 7vs6 (empty net) and 6vs6. Results showed that 5.9% of the total actions were played under 7vs6. Despite not having significant relationship, attack efficacy was better during 6vs6 (51,3%) than 7vs6 (42,4%).

Keywords: goalkeeper change; offensive performance; attack efficacy; number of players in court.

Introduction

Rules of the game in handball suffered one of its last most important modifications in 2016, which had a direct and massive impact on the development of the game, mainly at the elite level. This modification in rule 4.1 allows the exchange of the goalkeeper for any court player without the need to use a distinctive vest (IHF, 2016).

In a more current way, and by Flores-Rodriguez and Ramírez-Macías , in press; Krahenbühl, Sousa, Leonardo, Galatti & Costa, 2019; Prudente, Cardoso, Rodrigues & Sousa, 2019; Musa et al, 2017 and Spate (2020) under the current rules.

The game using the exchange of a goalkeeper for a field player in handball has been studied by Antón (2010) in tournaments played with the 2010 IHF game regulations. Román Seco (2019) in his analysis of the change of rules thorough a period of time, mentioned that one of the main reasons is the need to make the sport more attractive. In addition, these changes have made, for example, the game itself faster after the throw off modification. The last modification seemed to be focus more on an aesthetic improvement (goalkeepers were previously allowed to be changed by a court player provided this player may use a torn shirt in order to recognize his number). However, the change has ended up in real modifications in the way some teams play, impacting in both: the numerical context of players in court and the identification of roles (goalkeepers and court players).

Within the development of a match, coaches make use of this rule as a strategy or a tactical resource in a systematic or specific way (Beiztegui-Casado, Oliver-Corona and Sosa-González, 2019). Some coaches stated that they prefer to use this strategy during exclusions rather than 6vs6 moments (Krahenbül, Menezes & Leonardo, 2019). On the other hand, Krahenbühl, Sousa, Leonardo, Galatti and Costa (2019), suggest that the use of a seventh player in the attack does not reflect a direct benefit in the game. Being a relatively recent regulatory modification, it is still difficult to interpret whether the use of this strategy can benefit or harm the teams that use it.

Prudente, Cardoso, Rodrigues and Sousa (2019) studied 20 games of the 2017 men's world handball championship, observing a total of 990 offensive actions and registering 17 offensive actions in a 7vs6 EN context. Flores-Rodríguez and Ramírez-Macías (2021) carried out a study of the last stage at the 2019 men´s handball world championship, observing that in total, the use of the rule 4.1 to generate numerical superiority represented 4.6% of all attacks. On the other hand, The attack efficiency of the teams that used this strategy in the 2019 men's adult world championship was 48.7% (Spate, 2020). Krahenbühl, Pereira, Menezes, Amazonas & Leonardo (2021) found that the attack efficacy was 44.1% during the 2017 women's world championship. Bonjour and Tortajada (2019) analysed attacks without goalkeeper in the women's EHF Champions League 2018-2019, finding out that when using rule 4.1 the offensive efficiency was 35.5%, however, when observing the situations where rule 4.1 was used to produce numerical superiority, they observed that the offensive efficiency it was above 45%.
Based on the above, it is evident the importance of studying the offensive aspects of teams in both context: numerical equality and during exclusions. It appears to be a lack of numerous studies in the hole game time of numerical equality context. For this reason that the objective of this research was to compare offensive situations during 7vs6 empty net (EN) attacks with 6vs6 attacks at elite male handball during the period 2017-2020.

Methodology

Sample consisted of a total of 1451 offensive actions belonging to the 16 matches of the semifinals, third and fourth place and final of the 2017-2019 World Championships and the 2018-2020 European Championships. The teams analyzed were Germany, Norway, Denmark, France, Slovenia, Spain, Croatia and Sweden. The study followed the observational methodology procedures (Anguera and Hernández, 2013). An ad hoc observational instrument was developed by combining the field format and category system. A recording instrument was developed by using the Lince software (Gabín, Camerino, Anguera & Castañer, 2012).

Offensive actions where at least one of the teams had a 2 minutes exclusions were not registered. However, finalizations ending in 2 minute exclusions for the opposite team were registered. In addition, for the analysis of attack efficacy, the classification elaborated by Gutiérrez, Fernández and Borrás (2010) was used, which includes three categories: *negative finalizations* (technical-regulatory error or with a recovery of the ball as a consequence of a successful action defense), *positive finalizations* (shot on goal but not a goal; defense blocks the shot; the goalkeeper saves, the shot goes wide or hits the post) and *successful finalizations* (goal).

After collecting the data, they were analyzed using Microsoft Excel and SPSS 25 software (SPSS, Chicago, 2013). For statistical analysis, the Pearson Chi-square coefficient test was performed, the value of Cramer's V coefficient was calculated, as well as the values of the corrected residuals.

Results

Results showed that within the analysed championships 1365 situations of numerical equality 6vs6 (94.1%), and 86 situations of 7vs6 (5.9%) were registered. The EN situations with the aim of generating a 7vs6 superiority presented their highest utilization values in 2017 (9,7%), decreasing

throughout the championships, being the 2019 World Championships with a 0.6 % the year that registered the less used of 7vs6 EN (Figure 1).

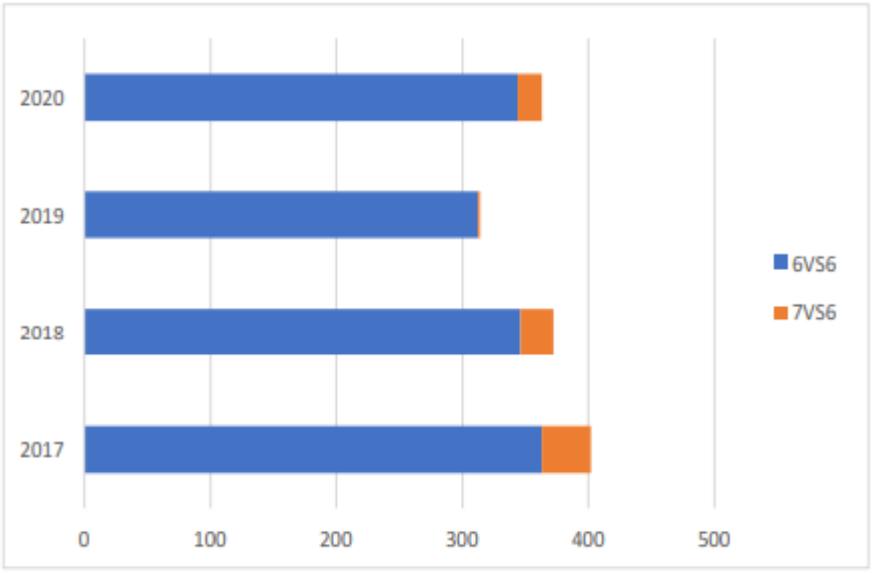

Figure 1. Distribution of the use of 6vs6 and 7vs6 numerical relationship during 2017-2020 period.

Regarding attack efficacy (AE) an overall efficacy of 52.6% was observed. When considering the numerical relationships, no statistically significant relationship ($p > 0.05$) was found between finishing in goal or not, and playing 6v6 or 7v6 EN. However, remarkable is to say that the AE during 6vs6 situations was higher (51.3%) than during 7vs6 EN situations (42.4%) (Table 1).

Table 1. Analysis of the finalizations actions during 6vs6 and 7vs6 EN.

	Goal	**No goal**	**Attack Efficacy**
6vs6	668	635	51.3%
7vs6 EN	36	49	42.4%
Total	704	684	52.6%

When discriminating the offensive finalization actions in five variables (goal, saved, blocked, missed and turnovers) no statistically significant relationship was found ($p > 0.05$). However, it can be deduced that both in 6vs6 and 7vs6 EN, the turnovers are similar (237 of 1303 for 6vs6 actions and 15 of 85 for actions 7vs6). Therefore, teams tend to finish in throwing more than 80% of their attacks (1066 out of 1303 during 6vs6 and 70 out of 85 during 7vs6 EN). Main differences are found in saved and blocked shots, where teams presented a better performance indicator during 6vs6 than 7vs6 EN (Table 2).

Table 2. Discrimination of finalizations during 6vs6 and 7vs6 EN offensive actions.

	Goal	Saved	Blocked	Missed	Turnover
6vs6	51.2%	20.4%	2.8%	7.3%	18.3%
7vs6 EN	42.4%	27.0%	5.9%	7.0%	17.7%

From the total 1451 finalization registered, 63 ended in a 2 minutes exclusions. When using the previous concepts of *successful, positive and negative finalizations* (Gutiérrez, Fernández and Borrás, 2010), no statistically significant relationship was found between the assessment of the finalizations and playing 6vs6 or 7vs6 EN ($p > 0.05$). However it is remarkable to mention that *positive finalizations* (saved, blocked, missed and 2 minute exclusion) presented a better indicator during 7vs6 EN than 6vs6 and that *successful finalizations* (goal) where better during 6vs6 than 7vs6 EN (Table 3).

Table 3. Discrimination of type of finalization (successful, positive and negative) during 6vs6 and 7vs6 EN.

	Successful	Positive	Negative
6vs6	48.9%	33.7%	17.4%
7vs6 EN	41.9%	40.7%	17.4%

Discussion

In the present study, most of the teams used the option of changing the goalkeeper for a player in situations of equality, generating a situation of 7vs6 EN numerical superiority of court players, coinciding with what Antón (2019) stated, who asserts that from the regulatory modifications Rio 2016, a widespread use of this strategy has been envisioned by most clubs and national teams in many countries. The decline in the use of the rule from 2017 to 2020 it may refer to the fact that coaches and players did not observe such an positive consequence in their constant use, as they did see during numerical inferiority situations.

Bonjour and Tortajada (2019) observed that when using rule 4.1, the offensive efficiency in the 2018-2019 women's handball Champions League was 35.5%, however, when observing the situations where rule 4.1 was used to produce numerical superiority , observed that the offensive efficiency was above 45%. Although the present study did not evaluate all the situations where rule 4.1 was used in order to produce numerical superiority, but only one of those situations (7vs6 EN), the offensive efficacy of the present study in actions of 7vs6 EN (42.4%) is similar to that reported by Bonjour and Tortajada (2019). Some differences were found between the attack efficiency in this study and Prudente, Cardoso, Rodrigues and Sousa (2019), which may be due to

the fact that the present study only evaluated the matches where these four best selected of the tournament faced each other in the semi-final instances, final and match of third and fourth place, while Prudente, Cardoso, Rodrigues and Sousa (2019) evaluated all the matches that these teams played. This information suggests that during the clashes with teams that failed to advance to the final stages of the tournament, the offensive effectiveness in 7vs6 EN actions by the teams that were ranked among the best four of the tournament is higher than when these teams face each other. This may be due to a greater defensive capacity on the part of the teams with a higher level against these actions. According to Antón (2018), the advantage that the use of 7vs6 actions may suppose could decrease over the years due to the improvement in specific defensive training for this type of actions.

Attack efficacy was better during 6vs6 than 7vs6 EN. Reason of this could be that during inferiority context, defenders react in a more aggressive way having an impact in their attitude towards defend the opposite teams actions (Bar-Eli et al., 1990). Another important issue is the relationship of space per player. Due to the anthropometric characteristic of players, adding a court player in the positional attack area, reduce the space between players and therefore in the mobility of them during the offensive phase (Prudente et al., 2019). Therefore the possibilities of causing 2 minutes exclusions are higher, being the reason why positive finalization are better in 7vs6 EN than 6vs6. The same fact of space and mobility may explain the fact of having differences in the number of saved and blocked shots. However, deeper research should be done in order to explain the reasons of this indicators.

Conclusions

The use of rule 4.1 with the aim of generating a numerical superiority of 7vs6 EN, was decreasing throughout the analyzed championships, accompanied by a decrease in its novelty and a decrease in its levels of effectiveness.

The game 6vs6 presented better offensive performance than 7vs6 EN offensive situations during the final stages in elite championships. This difference was evidenced in the shots blocked by the defense and saved by the goalkeepers. However, during 7vs6 EN context, *positive finalizations* are higher than 6vs6 context, giving the possibility to use this strategy not only for scoring reasons.

Further research and discussions considering coaches' opinion, might be pertinent to develop in order to study the use of this new rule. The match status, game time and numerical inequality context could be taken into account in order to evaluate the impact and use of this starategy.

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EFFECTS OF BILATERAL EXERCISES IN YOUTH'S HANDBALL – A RESEARCH PROGRAMME IN PROGRESS

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Abstract

Research in various sports indicates that systematic and specific bilateral exercises show positive effects on different factors of athletic performance, e.g., on the quality of skills, on tactical intelligence, and on creativity as well as on the prevention of muscular imbalances. However, and in particular with regard to handball, the state of the art is not highly advanced. As a consequence, we have been conducting a research programme in cooperation with the German Federal Institute for Sports Science (BISP), the German Handball Federation (DHB), and the Handball Federation of Württemberg (HVW) to find answers for some of the most interesting questions concerning the effects of bilateral exercises in children's and adolescents' handball. Among others, these issues affect the outcomes of a specific intervention programme for improving tactical behaviour, athletes' motivation, a balanced muscular system, and a qualitative approach for theory building.

Keywords: Bilateral exercises, tactical intelligence, game test situations, field study, theory building.

Introduction: Research Framework

Research on bilateral exercises shows that a specific and regular training of the non-dominant side of the body has various positive effects on skills and on tactical behavior. In this context bilateral exercises in handball are defined as the repeated and systematic application of both hands in drills and games in order to learn or to improve both skills and abilities. Hence, bilateral exercises should not only be applied during the learning process (skill acquisition), but also and in particular for automatisation as well as for the stabilization and variation of skills. A bilateral approach seems most relevant in disciplines that are characterized by a so-called functional dominance of one side of the body, e.g., like handball or football. All in all, the following advantages of bilateral training are reported and might be relevant for handball:

- *Technical proficiency and tactical capacity.* Studies from various sports show that bilateral exercises lead to higher learning effects as to both the quality of skills (Stöckel, 2010) and tactical behaviour (Guilherme et al., 2015).
- *Aspects of prevention and rehabilitation.* Various studies have reported that bilateral exercises have a positive effect on muscular asymmetries. Such imbalances may affect different physical parameters negatively (Parrington & Ball, 2016).
- *Talent scouting.* Meanwhile it seems to be widely accepted that the capability of acting with both hands can be an advantageous issue in the scouting process (Pabst & Scherbaum, 2018).

- *Attractiveness of lessons.* Cotê et al. (2007) found out that monotony is one main reason for dropout. Consequently, bilateral exercises may help to confront players with new challenges in motor behaviour while remaining specific within the sport context.
- *Skill optimization.* Some biomechanical approaches (e.g., Sachlikidis & Salter, 2007) have brought to light that bilateral training has an effect on the precision and speed of throwing skills.

However, there are only few studies which have tested these theoretical assumptions and insights under the conditions in the field, i.e., in everyday praxis of adolescent handball teams. Thus, we have developed a research programme which consists of two phases:

- In phase 1 (*pilot study*) we focused on the effects of bilateral exercises on the functionality and flexibility of adolescent athletes' skeletal muscles as well as on skill quality and throwing velocity. In addition, we explored the athletes' acceptance of exercises with the non-dominant hand. This research strand has already been finished.
- In phase 2 (*main study*) our focus is on tactical decisions (game intelligence) of 11 and 12 years old handball players and on an analysis of experts' attitudes towards bilateral exercises and its background. The latter issue corresponds with the idea of theory building.

In sum, the effects of bilateral exercises in juvenile handball seem to be both a research desideratum and a promising approach for improving the quality and effectiveness of the training process. In the following chapter we will show how we approached this issue with a multimethod research study.

Method

Our studies were designed as either intervention studies in the field or oral inquiries, thus following the quality criteria of quantitative or qualitative research. The following research objectives were addressed, whereby the study strands having been marked with an (*) were part of the pilot study:

(1) Analysis of the effects of a bilateral training programme on …
   - … tactical intelligence and creativity of juvenile handball players,
   - … the layers' functionality and flexibility (*).

(2) Development and validation of a test method for measuring tactical performance in everyday situations.

(3) Athletes' acceptance of exercising with the non-dominant hand (*).

(4) The building of a sport specific theory of bilateral training on the basis of an expert approach.

(5) Development and evaluation of an age-appropriate and developmental programme for improving the tactical capacity of 9 to 12-years old handball players.

The pilot study's time structure encompassing a cluster randomized control trail and the interviews is displayed in figure 1. The main study was designed alike, however without being able to implement the principle of crossover due to Corona pandemic and less time (cf. figure 4).

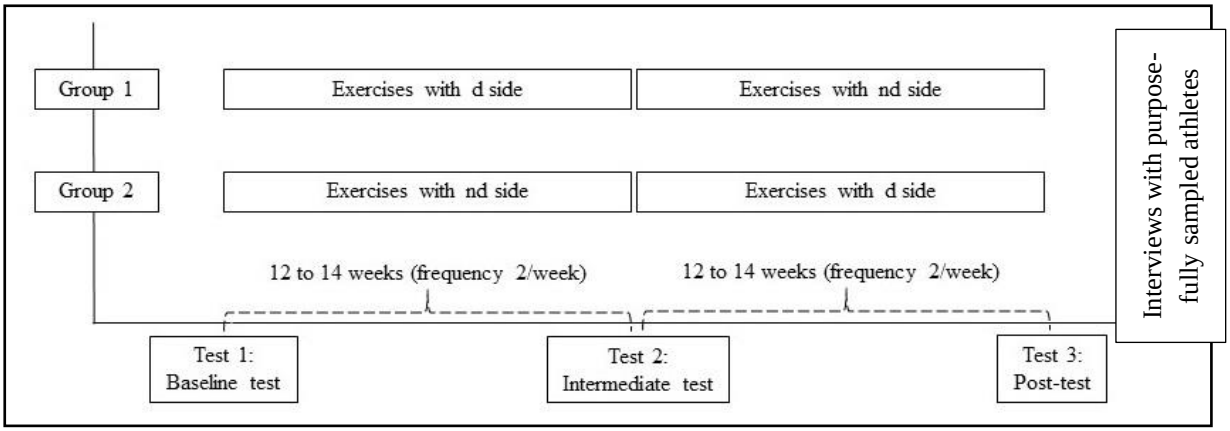

Figure 1. Time structure of the pilot study.

As to data collection and data analysis we implemented the following instruments, analysis tools, and procedures:

- *Body functionality and flexibility* were measured by means of the Y-Balance test (Neves et al., 2017) and the Functional Movement Screen (Cook et al., 2014) at three test points (baseline, intermediate, post-test). Additionally, the Landing Error Scoring System (Padua et al., 2015) was applied to analyse if the athletes were able to land correctly in a plyometric jump.
- *Tactical intelligence* was measured with specific test situations in which the participants had to solve rather simple and standardized situations (Memmert, 2004). These were videotaped and validated by three independent experts on the basis of a validated nine-level rating scale.
- Both quantitative strands were analysed using statistical methods, e.g., descriptives, effect sizes, and analysis of variance with repeated measures (rANOVA).
- Both the guided interviews with athletes (pilot study) and experts (main study) were transcribed and analysed via qualitative content analysis (Kuckartz, 2014) using MAXQDA 18 & 20.
- Finally, the age-appropriate and developmental programme was evaluated by interviewing the participating team coaches.

Results

Currently, we can report the following results:

Pilot Study (2018–2020)

(1) Body functionality and flexibility

Among others, less trained handball players tend to show muscular asymmetries in the shoulder girdle (see figure 2a). This may be attributed to a functional dominance of one side and urgently asks for preventive exercises, regardless of which form they are.

Furthermore, we found that a majority had considerable problems in the LESS-Test; we assume that this may lead to injuries in the near future. Figure 2b shows an examples of the issue.

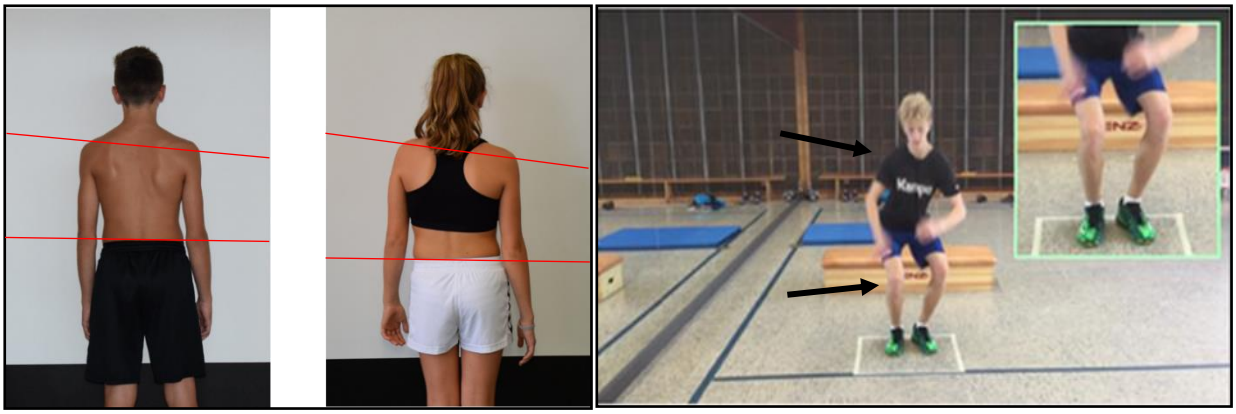

Figure 2a/b. Examples of shoulder asymmetry and LESS analysis. Notice the asymmetrical scapulae, feet, knees, and rotated trunk in both photos.

Our approach was to counteract these pathologies and to test the effects of a specific intervention with standardized bilateral exercises. The following results can be reported:

- In general, the majority of the participating handball players shows both deficits in basic movement patterns and bad functional parameters as well as large differences between the sides and an increased risk of injury.
- Considering the results of the FMS-Tests, both groups show a significant decline from test 1 to 2 ($F_{(1;39)}$ = 19,810, p = .000, η^2 = .337); however, we have to take into account that group 2 (non-dominant side) had a lower decrease which was not statistically significant ($F_{(1;39)}$ = .709, p = .405, η^2 = .018). This reduction in the test score may be attributed to both a change in the testing time (afternoon ⇨ morning) which was necessary due to organizational conditions and the early period of the season which seems to have triggered a great deal of injuries.
- Similarly, both groups improved significantly from test 2 to 3 ($F_{(1;32)}$ = 11,915, p = .002, η^2 = .271); again group 2 (n-d before d) obtained better results. However, the group difference was not statistically significant ($F_{(1;32)}$ = 2,251, p = .143, η^2 = .066).
- Results of the Y-Balance Test show that the rate of injury risk decreases more after exercises with the non-dominant side. Thus, bilateral training can make a contribution to prevention.

Summarizing the results of the pilot study we can carefully conclude that bilateral exercises following the order non-dominant before dominant lead to a better score in the FMS and a lower injury risk; hence, this method seems to be more effective as to muscular dysfunctionality than pure dominant exercises.

(2) Athletes' acceptance of bilateral exercises

Guided interviews have shown that bilateral exercises, in particular with the non-dominant hand, seem to be appreciated by the athletes. The main reasons for this assumption are:

- At the beginning of the training programme, the players notice a weaker musculature on the non-dominant side and describe a remarkable increase in strength and an improvement in fatigue resistance as a result of the exercises: *'For example, you can catch with your left hand, because the muscles in your hand are much stronger now'* (I5: 132–133).
- Technical improvements are perceived in various handball-specific movements (catching, passing, bouncing and throwing): *'[I] catch [...] much better with my left hand than I normally do, because ball control with my left hand, throwing and catching have become much better'* (I7: 107–109).

- The players describe that bilateral training leads to an improvement in tactical behaviour, in terms of their variability and repertoire of actions during the game, and produces advantages over the opponent: *'For example, when we counterattack, an opponent comes from the right and then you just bounce left and pass'* (I1: 96–97).
- The players express various reasons that stimulate their motivation to perform. An expanded repertoire of actions and greater variability due to a two-sided competence are perceived as particularly significant: '*Because you can use it in the game and you are also more variable when you need it, like when you can only throw with one hand'* (I2: 217–219). An increased enjoyment of training and training variety are regarded as further motivations to train bilaterally. Idols and role models who act bilaterally are also regarded as an incentive. In addition, it is mentioned that in case of an injury on the strong side, the opportunity to play can be maintained through bilateral competence.
- Overall, an increased motivation to perform was evident in most of the young handball players as a result of the bilateral training. All players report that they enjoy the additional training with the weak hand: '*I have a bit more fun because I know that this is for me*' (I1: 67–68).

(3) Skill quality

Skill quality has exemplarily been measured using the example of the straight shot. We found the following results based on velocity measurement with the Sport Pocket Radar Traffic Advisor™ and a qualitative evaluation with a specific rating sheet.

- First, bilateral exercises lead to a statistically significant improvement in the movement speed on both sides (d side: $F_{(1;27)} = 12{,}550$, $p < .001$, $\eta^2 = .317$; n-d side: $F_{(1;27)} = 10{,}077$, $p < .001$, $\eta^2 = .279$).
- Second, bilateral exercises had clear effects on the technical quality. However, no statistically significant differences between exercising with the non-dominant ($F_{(1;27)} = 9{,}932$, $p < .001$, $\eta2 = .276$) and the dominant side ($F_{(1;27)} = 22{,}867$, $p < .001$, $\eta2 = .459$) could be detected.

Main Study (2020–2022)

Initially, we have to call in mind that the main study is still in progress. This especially applies to the cluster randomized control trial (CRCT) with which tactical competence is analysed. Nonetheless, we are able to account some preliminary results:

(1) Current status and preliminary results from the expert interviews

Expert interviews ($n = 12$) were conducted in July and August 2021. The sample consisted of 4 specialists for children's handball, 4 handball teachers from universities and 4 sport scientists with a focus on the science of training or on movement science. The interviews were recorded, transcribed, and analysed with Qualitative Content Analysis (Kuckartz, 2014).

Currently, we can report that our participants regard bilateral exercises and its benefit for juvenile handball players differently. In detail they answered some of our questions as follows:

- First, they assess the significance of bilateral training in general as average (5 on a 10-point rating scale); however, the range of the answers stretches from 1 to 8.
- Second, this assessment proves itself as rather stable with regard to children's training, but on a higher level: The average assessment is 6.75 with a range from 1 to 10. The highest mark is justified with arguments like "I would give it a clear 10 [...] It develops the children so that they are much more flexible in their choice of action. They are more versatile. They can play just

about anywhere on the field. They are not limited. But at the same time, the child's brain develops much better. So it's not just an effect that relates to handball itself. It also develops the pathways in the brain. […].” (I12: 28–29), the lowest with “I would say 1 now. Bilateral training is not important if I am doing something performance-oriented. But there can be other goals, then it suddenly becomes important.” (I10: 58–59)

All in all, there still seems to be an enormous research desideratum as to the theoretical basis for bilateral exercises in handball training. Nevertheless, we have the impression that there is a tendency to give it a higher value in everyday praxis.

(2) Current status and preliminary results from the CRCT

Two waves of data collection have been finished. They took place before and after the summer holidays of 2021 (distance of time: 7 weeks) and were implemented to get a first impression of tactical competence over time without any purposeful intervention (cf. figure 4).

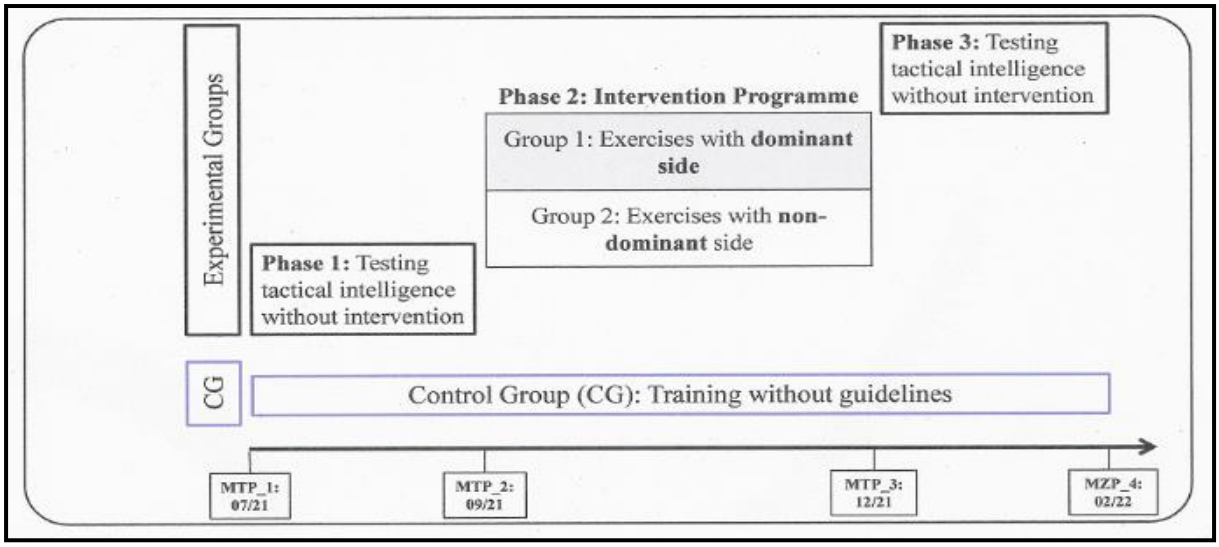

Figure 4. Time structure of the CRCT in the main study.

As to this part of the research programme data is currently analysed with three objectives:

- Validation of the test situations 1 to 3 computing interrater reliability (ICC).
- Computation of the performance level over time (rANOVA).
- Analysis of a longer break (holidays [phase 1] and regular exercises [phase 3]) on tactical performance (rANOVA).

Discussion

Integrating our various results on bilateral exercises in children’s handball training we found out that they confirm the need for injury prevention and for functional training contents, a demand to which bilateral training can make a contribution to. In addition, and with regard to skill optimization, bilateral exercises can improve both the throwing velocity on both sides and the quality of specific techniques like the slap shot. Furthermore, it seems to be useful to integrate exercises with the non-dominant side into the training of younger age-groups (8 to 12 years) to benefit from collateral processes. Finally, an increased motivation to perform was evident in most of the young handball players as a result of the bilateral training.

Regarding our assumptions in detail, we have to admit that the question of "how much?" is still unsolved. In our pilot study the athletes realized exercises over 12 weeks with the non-dominant for 60 minutes per week. This is doubtlessly a fraction in contrast to the amount of training with the dominant hand. Beyond that, we cannot deny that a rather low appreciation among the coaches could be noted. Insofar we apprehend a rather small readiness to implement bilateral exercises into everyday praxis. Both issues need further research and persuading.

Conclusion

Summarizing our research in its current state we can say that we have learned a lot about muscular dysbalances and asymmetries as well as about deficiencies in basic movement patterns in our pilot study. Differences between the two sides of the body may increase injury risk during the season, less developed skills may reduce the performance in the matches.

After all, from our point of view an integration of bilateral exercises into everyday practice is highly recommended as to the following reasons:

- All in all, juvenile handball players show rather bad functional parameters.
- Bad quality also applies to relevant skills.
- To a great extent our participants rated he exercises as interesting and rich in variety.

Despite the rather positive evaluation one should reflect the following aspects: We believe that bilateral exercises should be integrated as early as possible in athletes' long development physical development (Lloyd & Oliver, 2012); and it is still unclear in which relation as to time exercises with the non-dominant and the dominant side should be.

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POSTER PRESENTATIONS

INFLUENCE OF GOALKEEPERS ACCURACY INTO FINAL SCORE

EHF CHAMPIONS LEAGUE

David Aguilar Cardona
EHF Master Coach

Summary

Among the most trendy opinions and views into nowadays' handball, it's so usual to hear about how important goalkeepers' performance are in regards to the final score of a single game or even a whole competition, both from club or national teams or at European or world level.

Over the last years, goal-keepers' training has impressively raised the bar, especially when it comes to a more specific and individually tailored approach and with an increasing presence of video analytics as well, whose exclusive feedback can be easily leveraged and therefore allow them to push up their chances to make a difference into the final score of the games.

The present work is based on a sample of 112 games, belonging them to groups A and B from VELUX EHF Champions League group phase. Out of this data we'll try to figure out how strongly linked are these two variables: goal-keepers' accuracy and teams' success at the end of the games.

Introduction

VELUX EHF Champions League it's the main clubs competition played in Europe, joining the 24 best teams among the whole European handball scene. The competition flows as explained in the following points:

a. Teams are splitted out in 2 groups of 8 teams (A and B) and 2 ones of 6 (C and D).
b. Groups A and B: Both are disputed under a double round-robin basis, which means 14 fixtures. The winners of each group will qualify directly to quarter finals whereas runners- up from 2nd to 6th position will qualify to Last16. 7th and 8th will be eliminated.
c. Groups C and D: Double round-robin too, 10 fixtures in this case. Once this league is completed, the first two teams from each group will go through a qualifying round, in which the winners of each group will play a knock-out round against the second one from the other group. The two winners will gain the right to move on to Last16.
d. Last16: From here onwards the whole competition changes its shape from round-robin to knock-out style. Last16 reunites the following 12 teams:
    i. 5 coming from Group A (2nd, 3rd, 4th, 5th and 6th).
    ii. 5 coming from Group B (2nd, 3rd, 4th, 5th and 6th).
    iii. 2 winners from Groups C and D knock-outs.

All them will be placed into 6 duels of two legs each one. The one who scores more goals after both games will qualify for the next round. In the event of a tie, it will be broken firstly after an extra game and, if tie persists, victory will be decided after a 7-meters shootout.

The 6 winners will go through and meet with Groups A and B champions into the Quarter Finals.

- Quarter Finals: The remaining eight teams will get paired into 4 duels. Everything will work in the same manner as in Last16 and the 4 winners will meet into the Final Four.
- Final Four: The 4 qualified teams will meet in Lanxess Arena in Cologne (Germany) to play semifinals, 3rd-place match and final in a single weekend which will decide who's the new European champion. Aside of the neutral scenario, the only significant change is that knock- outs will switch from a double-leg basis into a single-leg one. Due to Covid-19 crisis, this current season 2019/2020 it's been decided the two first classified teams on groups A and B to qualify directly to the Final Four since it became impossible to find room into the calendar to place all the fixtures that would be necessary if we were to follow with the regular flow.

There are a bunch of studies that determine victory and defeat when high performant teams are involved do depend on some key offensive and defensive actions which are especially relevant, such as the ones from Pokrajac (2008), Taborsky (2008), Daza (2010), Montoya (2010) or Lozano (2012).

To illustrate how important goal-keepers accuracy is commonly considered among professionals, let's take a look on what happened with former FC Barcelona's goal-keeper Daniel Saric:

It was into 2014 Final Four when playing FC Barcelona against SG Flensburg-Handewitt, the formers wasted a 7-goals gap on the last ten minutes of the game, allowing the latters to come back and firstly equalize with a Holger Glandorf's buzzer-beater and finally win the game after two extra games and a penalty shootout, making this game one of the most remembered among handball fans worldwide.

Once the game finished, Saric broke down in tears while being interviewed and stated "I've played and awful game, I didn't stop a ball, I owe my club this trophy". A year passed and 2015 Final Four came. FC Barcelona was once again in Cologne with Saric defending its goal. He played a superb role stopping a huge deal of Veszprém's shoots during the final game, contributing dramatically into FC Barcelona's final victory.

The usual purpose of these kind of inquiries is to determinate what's the quantitative contribution from certain game features into some collective actions on elite handball teams. All this information is meaningful when it's time to design tactical or strategical approaches allowing us to optimize its performance.

Goal

The goal of this study is to statistically determine whether the goal-keepers' specific role, measured in saves accuracy percents makes a difference as believed or not. We'll only analyze this variable. The investigation will be quantitative, using the observational method.

Hypothesis

Our baseline hypothesis is that goalkeepers saves percentage is critical when it comes to determine the final result of a competition.

Method

In this observational-notational nature study, the data were compilated through the observation of a bunch of 112 games corresponding to all the matches from VELUX EHF Champions League 2019/2020 groups A and B, being supported too by the official reports published by the EHF. We'll get the GK's accuracy percentages from each one of these games, both for the whole 60 minutes of each one and broken down onto their two periods, in order for us to be able to infer more accurate insights and conclusions.

Results

3.1. Group Phase. Groups A and B.

Look at the table below in order for you to be able to check on each one of the games analysed. Each row contains information about when was each match disputed (column 'Date'), which were the teams involved ('Game'), what was the final score ('Home' and 'Away' columns), and what was the overall accuracy from each teams' goal-keepers (columns '% GKS Home' and '% GKS Away').

In order to make the table more insightful, find highlighted in green all the games in which the final score matched my initial hypothesis whereas those in which this did not happen are highlighted in red

Date	Game	Home	Away	% GKSHome	% GKS Away
14/9/2019	Montpellier - Vardar	31	32	21,95	18,42
14/9/2019	Pick Szeged - Barcelona	32	30	30,23	21,95
14/9/2019	Porto - Meshkov Brest	27	25	30,56	32,50
14/9/2019	Zagreb - Paris Saint-Germain	29	35	18,60	12,12
15/9/2019	Celje - Flensburg	24	25	32,43	35,14
15/9/2019	Elverum - Aalborg	24	34	24,44	36,84
15/9/2019	Kiel – Kielce	30	30	16,67	28,57
15/9/2019	Veszprém - Motor Zaporozhye	40	28	34,88	23,08
18/9/2019	Flensburg – Elverum	26	19	40,63	29,73
21/9/2019	Barcelona – Celje	45	21	41,67	13,46
21/9/2019	Meshkov Brest - Montpellier	25	27	28,95	30,56
21/9/2019	Veszprém – Kiel	31	37	21,28	29,55
22/9/2019	Aalborg – Zagreb	30	19	36,67	23,08
22/9/2019	Kielce - Motor Zaporozhye	34	26	29,73	15,00
22/9/2019	Paris Saint-Germain - Pick Szeged	31	25	32,43	31,11
22/9/2019	Vardar - Porto	32	26	27,78	21,95
25/9/2019	Kiel - Meshkov Brest	31	23	42,50	27,91
28/9/2019	Elverum - Paris Saint-Germain	22	25	32,43	35,29
28/9/2019	Pick Szeged - Flensburg	24	24	31,43	29,41
28/9/2019	Porto - Kielce	33	30	31,82	15,38
28/9/2019	Zagreb - Barcelona	19	36	20,00	52,50
29/9/2019	Celje - Aalborg	27	28	24,32	20,59
29/9/2019	Montpellier - Veszprém	23	20	47,37	36,11
29/9/2019	Motor Zaporozhye - Vardar	30	31	30,23	12,12
9/10/2019	Flensburg - Zagreb	20	17	46,88	39,39
12/10/2019	Barcelona - Elverum	32	24	35,14	21,95

12/10/2019	Kielce - Montpellier	25	29	23,68	26,47
12/10/2019	Meshkov Brest - Motor Zaporozhye	33	31	27,91	21,43
12/10/2019	Vardar - Kiel	19	29	25,64	44,12
13/10/2019	Aalborg - Pick Szeged	28	35	23,91	28,21
13/10/2019	Paris Saint-Germain - Celje	26	18	51,35	40,91
13/10/2019	Veszprém - Porto	38	28	33,33	26,92
19/10/2019	Barcelona - Paris Saint-Germain	37	32	30,43	21,28
19/10/2019	Meshkov Brest - Kielce	27	31	27,91	30,77
19/10/2019	Montpellier - Kiel	29	33	26,67	27,50
19/10/2019	Porto - Motor Zaporozhye	35	33	19,51	20,45
19/10/2019	Veszprém - Vardar	39	27	30,77	13,33
20/10/2019	Aalborg - Flensburg	31	27	28,95	35,42
20/10/2019	Celje - Elverum	32	27	30,77	28,89
20/10/2019	Zagreb - Pick Szeged	21	26	33,33	32,26
30/10/2019	Flensburg - Barcelona	27	34	30,61	32,50
2/11/2019	Kielce - Veszprém	34	33	21,43	26,09
2/11/2019	Paris Saint-Germain - Aalborg	37	23	36,11	19,57
2/11/2019	Porto - Montpellier	23	23	34,29	32,35
3/11/2019	Elverum - Zagreb	31	30	31,82	31,11
3/11/2019	Motor Zaporozhye - Kiel	27	27	37,21	28,95
3/11/2019	Pick Szeged - Celje	31	24	31,43	16,22
3/11/2019	Vardar - Meshkov Brest	36	30	16,67	18,18
6/11/2019	Flensburg - Paris Saint-Germain	28	30	28,57	20,00
9/11/2019	Meshkov Brest - Veszprém	29	35	23,91	27,50
9/11/2019	Vardar - Kielce	28	29	32,56	20,00
10/11/2019	Aalborg - Barcelona	29	35	23,91	34,09
10/11/2019	Celje - Zagreb	24	22	37,68	24,66
10/11/2019	Kiel - Porto	27	29	30,95	34,15
10/11/2019	Motor Zaporozhye - Montpellier	25	25	26,47	28,57
10/11/2019	Pick Szeged - Elverum	32	27	34,15	23,81
13/11/2019	Porto - Kiel	29	31	31,11	12,12
14/11/2019	Zagreb - Celje	28	32	20,00	24,32
16/11/2019	Barcelona - Aalborg	44	34	26,09	18,52
16/11/2019	Kielce - Vardar	32	25	35,90	20,00
16/11/2019	Veszprém - Meshkov Brest	31	25	28,57	29,55
17/11/2019	Elverum - Pick Szeged	25	26	16,13	32,43
17/11/2019	Montpellier - Motor Zaporozhye	33	29	21,62	26,67
17/11/2019	Paris Saint-Germain - Flensburg	30	31	29,55	31,82

20/11/2019	Kiel - Motor Zaporozhye	32	32	17,95	34,69
23/11/2019	Barcelona - Flensburg	31	26	40,91	22,50
23/11/2019	Meshkov Brest - Vardar	31	21	38,24	13,89
23/11/2019	Montpellier - Porto	22	29	9,38	35,29
23/11/2019	Veszprém - Kielce	29	24	27,27	29,27
24/11/2019	Aalborg - Paris Saint-Germain	29	31	26,19	35,56
24/11/2019	Celje - Pick Szeged	24	34	10,53	36,84
24/11/2019	Zagreb - Elverum	30	26	33,33	28,57
27/11/2019	Motor Zaporozhye - Porto	30	30	28,57	16,67
30/11/2019	Kiel - Montpellier	33	32	27,27	21,43
30/11/2019	Kielce - Meshkov Brest	30	23	42,50	28,57
30/11/2019	Pick Szeged - Zagreb	33	23	34,29	26,67
1/12/2019	Elverum - Celje	37	25	39,02	19,57
1/12/2019	Flensburg - Aalborg	29	32	27,27	27,50
1/12/2019	Paris Saint-Germain - Barcelona	30	36	30,77	26,83
1/12/2019	Vardar - Veszprém	29	36	14,29	19,44
5/2/2020	Kiel - Vardar	33	23	39,47	19,51
8/2/2020	Montpellier - Kielce	24	24	20,00	38,46
8/2/2020	Pick Szeged - Aalborg	26	26	33,33	38,10
8/2/2020	Porto - Veszprém	25	31	22,50	37,50
8/2/2020	Zagreb - Flensburg	25	25	24,24	28,57
9/2/2020	Celje - Paris Saint-Germain	29	33	21,43	30,95
9/2/2020	Elverum - Barcelona	25	30	33,33	35,90
9/2/2020	Motor Zaporozhye - Meshkov Brest	31	35	25,53	29,55
12/2/2020	Kiel - Veszprém	29	28	24,32	25,64
15/2/2020	Barcelona - Zagreb	30	24	35,14	28,57
15/2/2020	Elverum - Flensburg	29	34	15,00	19,44
15/2/2020	Kielce - Porto	29	25	39,02	25,64
15/2/2020	Montpellier - Meshkov Brest	30	25	40,48	21,05
15/2/2020	Vardar - Motor Zaporozhye	37	25	32,43	17,78
16/2/2020	Aalborg - Celje	28	23	43,90	34,88
16/2/2020	Pick Szeged - Paris Saint-Germain	32	29	27,50	27,27
19/2/2020	Flensburg - Pick Szeged	34	24	40,00	19,05
20/2/2020	Motor Zaporozhye - Kielce	27	33	26,67	37,21
22/2/2020	Meshkov Brest - Kiel	33	30	41,18	26,67
22/2/2020	Paris Saint-Germain - Elverum	30	25	34,21	16,67
22/2/2020	Porto - Vardar	30	23	39,47	28,57
22/2/2020	Zagreb - Aalborg	31	30	21,05	24,39
23/2/2020	Celje - Barcelona	24	36	20,00	27,27
23/2/2020	Veszprém - Montpellier	24	22	43,59	38,46

26/2/2020	Flensburg - Celje	28	26	23,53	34,88
29/2/2020	Barcelona - Pick Szeged	30	28	28,21	31,82
29/2/2020	Kielce - Kiel	32	30	34,78	25,58
29/2/2020	Meshkov Brest - Porto	32	35	23,91	33,33
29/2/2020	Motor Zaporozhye - Veszprém	22	31	29,55	45,00
29/2/2020	Vardar - Montpellier	27	31	24,39	30,77
1/3/2020	Aalborg - Elverum	30	28	30,00	23,08
1/3/2020	Paris Saint-Germain - Zagreb	37	26	35,00	21,28

Final Four. Qualified teams's specific analysis.

3.1.1. Final Four 2020.

Firstly, we'll take a glimpse at the GK saves accuracy among all the teams taking part into this group phase on the chart below. The teams highlighted in green are the ones who got qualified for the Final Four.

Team	Saves	Goals	% Saves
Barcelona	**187**	**375**	**33,27**
Veszprém	**171**	**382**	**30,92**
Flensburg	167	376	30,76
Paris Saint-Germain	**171**	**390**	**30,48**
Kielce	168	389	30,16
Pick Szeged	162	376	30,11
Montpellier	148	374	28,35
Meshkov Brest	168	426	28,28
Porto	160	406	28,27
Kiel	**154**	**397**	**27,95**
Aalborg	157	416	27,40
Celje	158	449	26,03
Elverum	144	416	25,71
Motor Zaporozhye	156	455	25,53
Zagreb	152	446	25,42
Vardar	117	431	21,35

As per the chart, we can easily check that 3 out of the top-4 teams in terms of GK saves percentage gained their right to be in Cologne. Only THW Kiel got a significantly lower figure than their upcoming opponents in Final Four 2020.

Final Four 2019.

Results

	Final	1st time	2nd time
1st semi final			
FC Barcelona – HC Vardar	**27 – 29**	**16 – 9**	**11 – 20**
2nd semi final			
Telekom Veszprém – PGE Vive Kielce	**33 – 30**	**13 – 13**	**20 – 17**
3rd – 4th place			
FC Barcelona – PGE Vive Kielce	**40 – 35**	**20 – 16**	**20 – 19**
Final			
HC Vardar – Telekom Veszprém	**27 – 24**	**16 – 11**	**11 – 13**

3.1.1.1. GK saves accuracy breakdown by game and period.

% Saves	Vardar	Veszprém	Barcelona	Kielce
Semi final 1st half	**36%**	**48%**	**44%**	**24%**
Semi final 2nd half	**35%**	**26%**	**13%**	**13%**
3rd - 4th place 1st half			**38%**	**33%**
3rd - 4th place 2nd half			**27%**	**17%**
Final 1st half	**31%**	**20%**		
Final 2nd half	**28%**	**31%**		
1st half average	33.5%	34.0%	41.0%	28.5%
2nd half average	31.5%	28.5%	20.0%	15.0%
Average in F4	32.5%	31.5%	29.5%	22.0%

As per the chart, it seems crystal clear how much relevant the goal-keepers' performance were in each game, especially in Vardar games. Both in their comeback on the second half against Barcelona on semi finals or along the first period against Veszprém as well, the huge gap between Vardar's goalkeepers performance

compared to Barcelona or Veszprém ones are strongly correlated with how the score evolved in both games.

Global insights

Summing up the main facts we've came across over all our analysis, these are the most relevant facts found.

- 81 out of 112 games were won by the team whose goal-keepers got the higher accuracy percentage.

- 39% accuracy: Every time the goalkeepers from any given team did surpass this threshold, their team always won the game. This fact took place in 22 occasions.

- 5% gap: Whenever the gap between the goalkeepers accuracy from both teams in the court was equal or higher than this figure, the teams whose goalkeepers were more effective did won 82% of the times this condition came into play.

- GK accuracy has played a key role for the leading teams on group phase to gain its qualification towards Final Four 2020.

- GK accuracy came up as a major fact for the last Final Four 2019 to be decided in favour of Vardar.

Discussion

Several works and studies had taken place over the past decades about the importance of goal-keepers role in handball, such as:

e. Suter (1975), Menéndez Falkowski and Enríquez (1979), Konig (1981), Román (1981), Torres Todibio (1983), Pokrajac (1985) and Antón (1990) reflected about its training specificities according to their singular role.

f. Closer on time, on season 2004/2005 the French Handball Federation published an article compilating the views about the matter and its singularities from some of the best goalkeepers from the 90's decade such as Mats Olsson or Bruno Martini.

Perceptive and decisional approach has gained a lot of interest over the last decade. Velandrín (2004) and Pascual and Peña (2006) published its investigations on this subject, proving that enhancing goalkeepers' perceptive-decisional skills is key in order to make a difference into their performance, and that their training tasks should focus more on the tactical approach based on this facts rather than a traditional technical-based approach, which should be a complement to the former.

Conclusions

As a result of all my analysis, the main conclusions I take away from it are the following ones:

Goalkeepers accuracy...

g. ... is key for any team to be successful in an elite competition such as EHF Champions League is.
h. ... can gain even a major relevance when top teams are opposed to each other in the event of top contests such a Final Four is too.
i. ... reduce the likelihood of a defeat to the lowest level:
    i. ...as much as it gets close to reach high figures, and makes it impossible from 39% upwards.
    ii. ...as bigger is the gap between both teams playing on this feature.

Therefore, any efforts to do in order to improve goalkeeper’s specific training in order to increase their performance are really likely to make a difference into their team’s success on elite competitions.

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STUDY ON THE IMPACT OF THE APPLICATION OF THE U21/U23 RULE IN THE WOMEN 'S NATIONAL LEAGUE

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Summary

One of the most common difficulties is how handball players are selected to play for high-level, open-age competition. The impact of the U21/U23 rule on the 24 U21/U23 players in the Women National League was analyzed through a survey. We conclude that the rule imposed by the Romanian Handball Federation, as applied in its current form, must be subject to amendments to ensure real playing opportunities for young talented players.

Keywords: *handball, performance, young player, transition*

Introduction

Career transitions as turning phases in career development involving appraisals of, and coping with, transition demands leading to successful or less successful outcomes and relevant changes in an individual's career trajectory (e.g., the junior-to-senior) (Stambulova et all, 2021).
The transition from junior-to-senior sports typically happens during players' adolescent years, but it is difficult to identify exact chronological age of entry to this transition because of gender, individual, and type of sport differences. The transition from junior-to-senior sports begins when individual sports athletes start to participate in the senior competitions in their sports and team sports players start to practice with a senior team and play for at least some time in senior games (Stambulova, Franck & Weibull, 2012).
Senior sports are characterized by more intense competition seasons, much stronger opponents, and higher publicity and financial incentives compared with the junior level. All of these create demands for transitional athletes in training and competitions (e.g., more intense, and deliberate practice and earnings visibility in senior competitions/matches) and in lifestyles and relationships, including, for example, optimal recovery; balancing sport, education, social, and private life; and renewing one's support network (Stambulova, Samuel, 2020). The key success factors of athletes' successful transitional experiences and environments include athletes' personal resources (e.g., athletic abilities, self-responsibility, and time management) and a supportive environment with available role models and professional assistance (e.g., medical, psychological), complemented by athletes' optimal interactions with coaches, teammates, peers, and parents (Stambulova & Samuel, 2020).
To ensure increased opportunities for U21/U23 Handball players to access the first teams, the Romanian Handball Federation proposed and implemented the rule according to which the teams have the obligation to use at least one player under 21 years old, on average 30 minutes per match and at least one player under the age of 23, on average 30 minutes/match. The average is calculated

by dividing the total number of minutes played by the athlete in a competitive season, the number of matches played by the team in National League, and the result must be greater than or equal to 30 and 30, respectively. If a team uses more than one eligible player in this situation, the average is calculated dividing the total minutes played by these athletes, to the number of matches played by the team in the season.
The objective of the present study was to assess the impact that the application of the U21/U23 rule has on players in transition from juniors to seniors.

Methods

Participants
Participants were 24 youth handball players from National Women League, of which 11 U21 and 13 U23.
To participate in this study, the handball players had to have started practicing with a senior team. All participants were fully informed about the aims of the study and written informed consent was obtained.

Instrument

In the development of the survey, the recommendations of Dyer (2006) were considered: the study of the specialized literature, the transformation of ideas into raw questions, the transformation of raw questions into survey items, the testing of the comprehensibility of the survey.
The survey consists of 5 closed questions, with 5 possible answers, related to: the way the players appreciate the U 21 rule; the help received by applying this rule; the correctness with which the coaches apply the rule; the extent to which the application of this rule ensures a place for the players among the 16 on the game sheet; and how this rule is viewed by their colleagues to whom this rule does not apply. Alternatives to answer the 5 closed questions included 5 options.
To the 5 closed questions are added 2 open questions, related to the emotional impact of this rule on the U21 and U23 players and how this rule could be improved in the future.

Development

The U21 and U23 players were asked to answer the survey after 1 year of applying the U21 rule in the Women's National League.
Results
Basic psychometric data on the survey are summarized in Table 1, 2, 3, 4, and 5, and in every Table, we present means (M).

Table 1

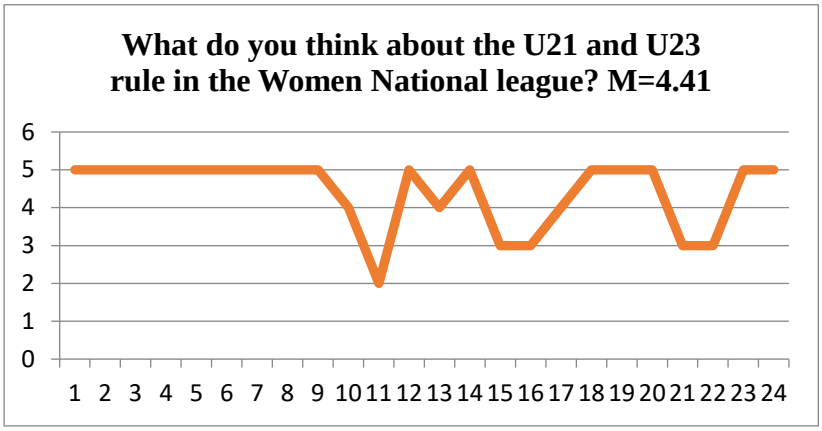
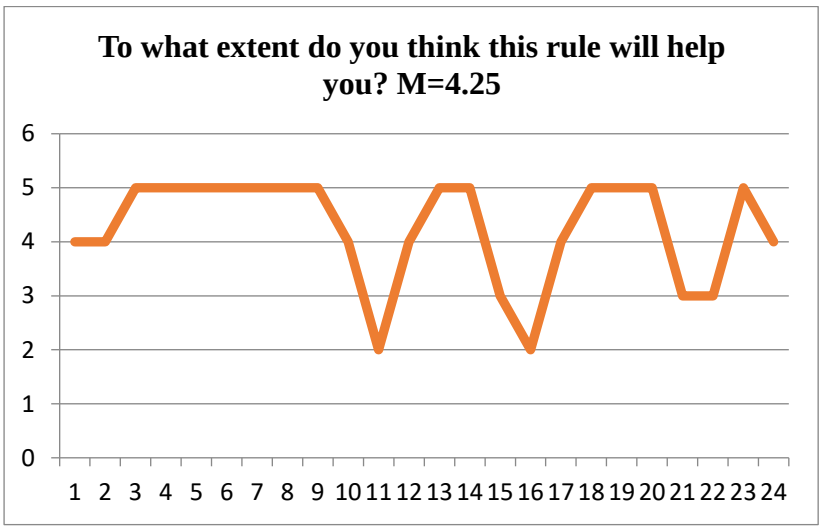


Table 2



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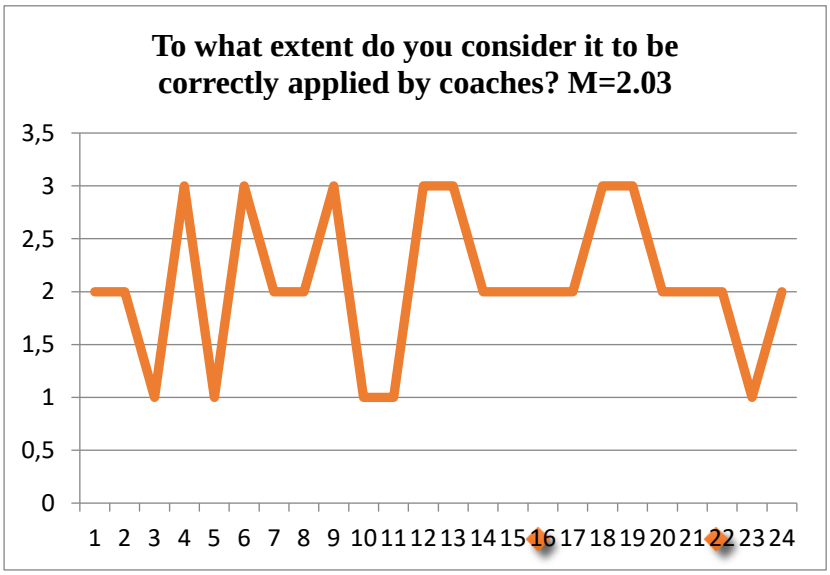


Table 4

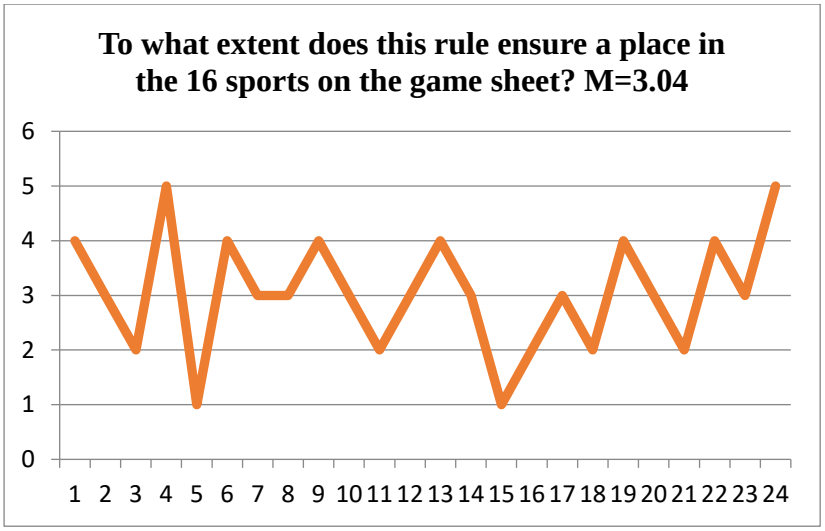
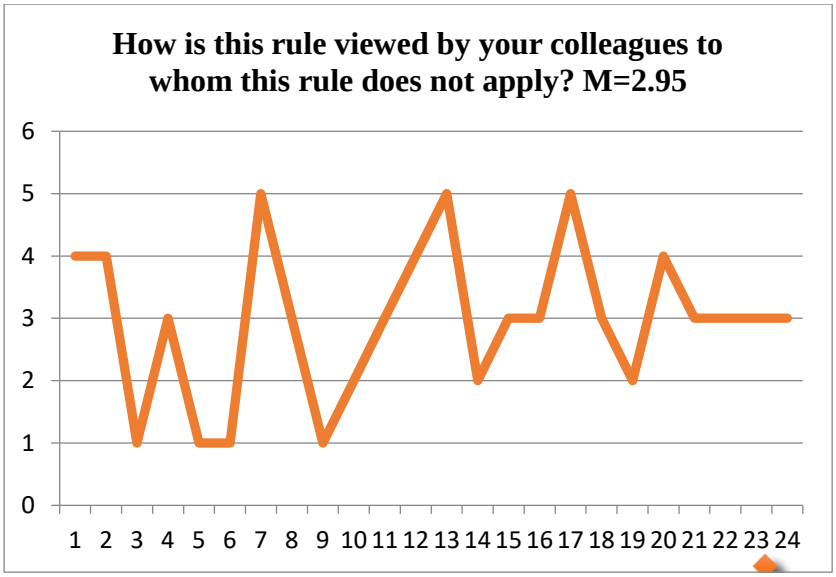


Table 5



Discussion

Of the means obtained for the 5 closed questions, the highest value was recorded in question 1 (M=4.41), considering the U21 rule very useful; the lowest value was recorded in question 3 ("To what extent do you consider it to be correctly applied by coaches?", M=2.03).

The introduction of U21 rules is seen by players as an opportunity to develop and gain more playing time, but some coaches do not apply it correctly, which can have a negative impact on the mental state of the players.

The answers to question 6 ("Briefly describe the emotional impact this rule has on you") vary on a continuum from "It is a positive impact because I feel that I will have the chance to play and so I will gain more confidence in myself and experience"; "It gives me hope that the coach trusts me and that he will put me on the field"; "Gain confidence when playing against seniors" to "It is a rule that helps me gain courage and confidence only if the coaches apply it properly"; "I consider

it a plus if it is imposed correctly", to a negative impact such as disappointment, stress, uncertainty, pressure: "It can be demoralizing because coaches use only one player to meet their time, but the rest of the younger players do not have this chance"; "Even if there is this rule, I do not feel protected by it, it does not assure me that I will play in the official matches in the National Women's League"; "At the moment, this rule is misinterpreted, leading to the abuse of the quality of the players in the age criteria. I believe that more attention should be paid to this issue as the emotional impact is beneficial and trustworthy."

The answers to question 4 ("How do you think this rule could be improved?") provide clarifications and proposals for improving U21 rule, with immediate effect on players: "Regardless of the number of players in a team that falls under this rule, they must have a minimum number of minutes in each match"; "In each match, the players should be introduced, not the mandatory minutes should be counted at the end of the championship"; "The rule could be improved by changing the fact that there must be an average of minutes at the end of the year. It would be best to impose a fixed number of minutes played on each game and validate the minutes in a truthful way. 10/30 minutes per match counted on the timer"; "With the involvement of each U21, U23 player and not just one player to get rid of the minutes required by the rules".

Conclusions

Ensuring a correct application of the U21 rule and adding the necessary clarifications can create the conditions for a beneficial evolution for the players to whom this rule applies.

Considering the data resulting from this study, within the Romanian Handball Federation it was decided to introduce, starting October 2021, a note on the accounting of one minute of play for rules U21, U23 and U25 in the rules of senior competitions: "One minute of play for players eligible for rules U21, U23, U25 will be counted only if the player has completed at least one attack phase or a defense phase". But this change does not solve the situation in which the players are used on the field only in matches without the pressure of victory (maximum 3 -4 matches per championship) and not every match the 10 minutes. These situations can be prevented by increasing the awareness of coaches about the obstacles in the development of players that such situations can bring.

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PHYSICAL FITNESS PROFILE IN JAPANESE ADOLESCENT HANDBALL PLAYERS

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Summary

The purpose of this study was to clarify the anthropometric and physical fitness characteristics of Japanese adolescent handball players. The elite court players were significantly taller, heavier and better in fitness variables, whereas no significant difference was observed in fitness variables between the goal keepers selected for elite category later and those who were not selected, except for one-handed handball throw.

Keywords: physical fitness, Japanese adolescent players

Introduction

Handball is a high intensity intermittent team sport that requires primarily aerobic capability, interspersed by anaerobic performance with maximal or submaximal efforts such as changes in pace and direction, jumps, throws and body-contacts (Póvoas et al., 2012). It has been reported that mean heart rate (HR) was 86% of maximum HR and the total distance was 5000m and more, which consisted of 9.2% sprints, 26.7% fast running, 28.8% slow running and 35.5% walking, in elite female handball field players (height: 175.2 ± 6.3cm weight: 67.8 ± 4.8kg) during the competitive entire games (2*30min.) (Manchado et al., 2013). Although the team handball performance is influenced by individual factors (e.g., constitution-disposition and nutrition), team factors (e.g., cognition, social factors and tactics) and external factors (e.g., material and environmental conditions) (Wagner et al., 2014), it would be still recommended that each player highly develops his/her physical fitness to achieve successful outcomes in competitions.

Physical fitness test is a common method in preventive and rehabilitative exercise programs and includes the following objectives: 1) demonstrating about current health-related fitness status, 2) providing data to effectively develop exercise prescriptions, 3) evaluating of progress by program participants, 4) motivating participants by setting goals and 5) stratifying the risk of cardiovascular disease (Walter et al., 2010). It is widely carried out in sports settings also, especially for young athletes to identify and develop their talents. The Japan Handball Association (JHA) has set up the National Training System (NTS) and conducted the physical fitness test for young players since 2009. The components of the physical fitness test by NTS have been revised 2 times so far. The NTS projects have been cancelled because of COVID-19 since 2020, thus the 3rd Revised Physical Fitness Test had been undertaken in the training camp from 2017 to 2019. It is important to provide comprehensive and updated normative data to maximize

his/her potential for success (Samantha, 2013). Therefore, the aims of this study were: (1) to describe the anthropometric and fitness characteristics of Japanese adolescent handball players during the years 2017-2019 based on school grade categories and (2) to evaluate the anthropometric and fitness variables based on their playing positions and performance levels.

Methods

Participants were 2,472 adolescent handball players (male = 1,249; female = 1,223) recruited from each region to the NTS Block Training Camp (BTC) 2017, 2018 and 2019 in total. All players were organized into age-based groups: U-13 (school grade: under 7^{th}; male = 558; female = 559) and U-16 (school grade: 8^{th} - 11^{th}; male = 691; female = 664). Also, out of players who participated in BTC, a few dozen players discovered their potentials by NTS coaches in the training camps were annually selected to the higher category after BTC. The total number of players selected to the elite category over three years was 375 (U-13 male = 88; U-13 female = 92; U-16 male = 96; U-16 female = 99).

The 3^{rd} Revised Physical Fitness Test included anthropometric and physical fitness variables. The anthropometric variables were height and body weight. The unit of measurement were 0.1cm and 0.1kg, respectively. The physical fitness variables were: (1) 30 m straight sprint test (30mSS) (unit of measurement: 0.1 second), (2) standing long jump (SLJ) (unit of measurement: 1cm), (3) one-handed handball throw (BT) (unit of measurement: 0.1m), (4) Illinois agility test (IAT) (unit of measurement: 0.1second), (5) SLJ to height (J/H) ratio and (6) IAT to 30mSS (I/S) ratio. In 30mSS, the subjects started from a standing position. The measurer whistled after confirming the starting position was stationary. The measurement was initiated by the movement of the subject after the whistle. The best time out of 2 attempts was recorded. In SLJ, the subjects two-footed jumped forward from a standing position and landed on both feet. The distance from the take-off line to the back of the closest heel on landing was measured. The maximal distance out of 2 attempts was recorded. In BT, the subjects placed toes on the edge of a line with the feet apart and throwed a handball with no steps. The distance from the standing line to the point of ball falling was measured. The maximal distance out of 3 attempts was recorded. In IAT (see Figure 1.), the subjects started from a prone (front lying face down) position with the elbows flexed, the hands under the chin and the palms on the floor. The measurer whistled after confirming the starting position was stationary. The subjects sprinted straight ahead to the first turning point after the whistle, then turned and sprinted diagonally back to the end marker cone in the center of the course. They then turned around the cone and weaved in and out around marker cones spaced 3.3 meters apart, turning back around the far marker cone. Then, they weaved again in and out around marker cones, turning around the end marker cone back and sprinting diagonally to the second turning point. They then turned on the second turning point and sprinted diagonally back to the goal point. The measurement was initiated by the movement of the subject after the whistle. The attempt was one time to be recorded. J/H ratio was the proportion of SLJ to height. The higher ratio indicated that the subject had better jumping ability. This index evaluated SLJ record by excluding the effect of height difference between subjects. I/S ratio was the proportion of IAT to 30mSS. The lower ratio indicated that the subject had better sprinting ability only when he/she had faster 30mSS record.

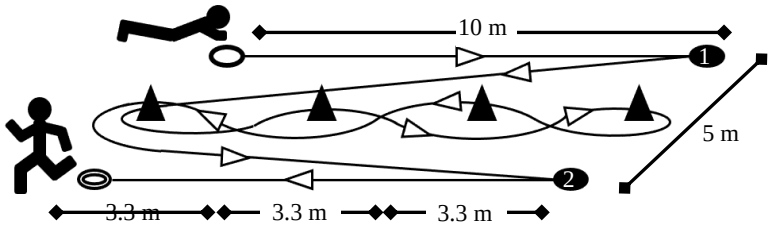

Figure 1. Illinois agility test

○ : start point, ◎ : goal point, ❶ : first turning point, ❷ : second turning point, ▲ : marker cone

All data obtained in this study were represented as mean ± SD. The data was calculated statistically by using the Mann-Whitney U test to compare the values based on playing position and performance level 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 to calculate.

Results and Discussion

The data of the subjects whose 30mSS records were over mean records (U-13 male: 4.89; U-13 female: 5.05; U-16 male: 4.33; U-16 female: 4.81) was excluded in I/S ratio. Also, the data of the subjects whose playing positions were unknown was excluded (Table 2., 3. and 4.). Table1.and 2. shows the anthropometric and fitness characteristics of Japanese adolescent handball players. The average height and weight of U16 male and U16 female were 175.6 ± 6.3 cm 66.7 ± 9.2 kg and 162.7 ± 5.5 cm 54.8 ± 6.1 kg, respectively. The taller and heavier players would take advantages in many situations during handball games. JHA has reported youth players would need the height and body weight (187cm 80kg for male; 173cm 63kg for female) to achieve better results in world competitions (JHA, 2020). The results revealed Japanese youth players were short of the required physique. The number of adolescent basketball players (school grade: under 6th) registered in Japan Basketball Association was 153,143 in 2019, meanwhile 6,719 adolescent handball players registered in JHA in 2019. The delay in the spread of the popularity of handball among youth could be one of contributing factors. There were significant differences in few variables in U13 elite categories but in most in U16 regardless of sex (see Table3.). Significantly greater differences for height and body weight preferred and 30mSS, SLJ, BT and IAT non-preferred were observed in goalkeepers compared to court players. This was likely because those who had better morphological properties, but relatively inferior physical

Table1. Physical fitness characteristics across age groups

variables		U13 (school grade: under 7th)		U16 (school grade: 8th-11th)	
		Male n=558	Female n=559	Male n=691	Female n=664
Height	(cm)	155.9 ± 9.7	153.9 ± 8.4	175.6 ± 6.3	162.7 ± 5.5
Body Weight	(kg)	45.3 ± 10.1	43.4 ± 7.1	66.7 ± 9.2	54.8 ± 6.1
30m Straight Sprint	(sec.)	4.89 ± 0.37	5.05 ± 0.33	4.33 ± 0.23	4.81 ± 0.28
Standing Long Jump	(cm)	199.2 ± 20.2	186.2 ± 15.5	236.8 ± 16.6	198.6 ± 14.7
Ball Throw	(m)	25.8 ± 5.0	20.6 ± 3.8	36.1 ± 4.9	25.0 ± 3.5
Illinois Agiliy Test	(sec.)	17.83 ± 1.15	18.48 ± 1.06	16.44 ± 0.77	17.74 ± 0.93
J/H ratio		1.28 ± 0.11	1.21 ± 0.14	1.35 ± 0.10	1.22 ± 0.10
		n=155	n=385	n=216	n=375
I/S ratio		3.80 ± 0.19	3.76 ± 0.17	3.89 ± 0.17	3.76 ± 0.16

Table2. Physical fitness characteristics across playing positions

sex	variables		U13 (school grade: under 7th)		U16 (school grade: 8th-11th)	
			court players	goal keepers	court players	goal keepers
male			n=453	n=71	n=527	n=112
	Height	(cm)	155.5 ± 9.9	159.0 ± 9.5	175.0 ± 6.4	178.1 ± 5.5
	Body Weight	(kg)	44.5 ± 9.5	51.0 ± 13.3	65.5 ± 8.2	72.1 ± 11.7
	30m Straight Sprint	(sec.)	4.86 ± 0.36	5.04 ± 0.44	4.30 ± 0.21	4.48 ± 0.26
	Standing Long Jump	(cm)	200.3 ± 20.0	194.9 ± 23.0	238.2 ± 16.3	230.1 ± 17.8
	Ball Throw	(m)	26.0 ± 5.0	25.4 ± 4.9	36.7 ± 4.6	33.0 ± 4.8
	Illinois Agiliy Test	(sec.)	17.73 ± 1.09	18.3 ± 1.34	16.31 ± 0.71	16.97 ± 0.84
	J/H ratio		1.29 ± 0.11	1.23 ± 0.12	1.36 ± 0.10	1.29 ± 0.11
			n=136	n=14	n=312	n=38
	I/S ratio		3.80 ± 0.19	3.82 ± 0.19	3.87 ± 0.17	3.92 ± 0.15
female			n=455	n=62	n=520	n=85
	Height	(cm)	153.6 ± 8.7	156.6 ± 5.9	162.1 ± 5.4	165.8 ± 4.9
	Body Weight	(kg)	43.0 ± 7.0	47.1 ± 7.3	54.2 ± 5.8	58.0 ± 6.3
	30m Straight Sprint	(sec.)	5.03 ± 0.33	5.22 ± 0.35	4.78 ± 0.24	4.99 ± 0.41
	Standing Long Jump	(cm)	187.0 ± 15.3	181.8 ± 16.5	199.3 ± 13.8	194.5 ± 18.1
	Ball Throw	(m)	20.8 ± 3.8	19.6 ± 3.8	25.3 ± 3.4	23.2 ± 3.0
	Illinois Agiliy Test	(sec.)	18.38 ± 1.03	19.20 ± 1.19	17.59 ± 0.76	18.54 ± 1.33
	J/H ratio		1.22 ± 0.15	1.16 ± 0.10	1.23 ± 0.09	1.18 ± 0.12
			n=193	n=35	n=315	n=30
	I/S ratio		3.75 ± 0.18	3.80 ± 0.14	3.75 ± 0.14	3.85 ± 0.22

fitness capacities had been selected as goal keepers, while this might be due to the accumulation of different training styles imposed by the different playing positions. It is difficult to suggest reasons for this finding and further research is required. Elite court players had significantly better values for almost all variables as compared to non-elite court players, whereas there was a significant difference for height and BT in U13 male, height, body weight and BT in U16 male, 30mSS, SLJ, IAT and J/H ratio in U13 female and height and BT in U16 female in elite goalkeepers versus non-elite goalkeepers (see Table 4.). These findings suggest it was hard to find out an individual's fitness level of goalkeeper only from his/her goalkeeping

Table3. Physical fitness characteristics of court players compared to goalkeepers

sex	categories	variables		U13 (school grade: under 7th)		U16 (school grade: 8th-11th)	
				court players	goal keepers	court players	goal keepers
male	elite			n=76	n=12	n=84	n=12
		Height	(cm)	164.0 ± 9.2	165.6 ± 6.9	178.5 ± 5.5	183.3 ± 4.7*
		Body Weight	(kg)	52.0 ± 9.0	57.0 ± 13.8	67.5 ± 7.9	79.0 ± 7.8***
		30m Straight Sprint	(sec.)	4.65 ± 0.29	4.93 ± 0.32**	4.26 ± 0.18	4.47 ± 0.17**
		Standing Long Jump	(cm)	213.2 ± 20.4	203.6 ± 26.8	243.4 ± 14.3	232.3 ± 13.8*
		Ball Throw	(m)	30.7 ± 4.5	29.5 ± 3.3	39.2 ± 4.5	36.6 ± 4.0
		Illinois Agiliy Test	(sec.)	17.08 ± 0.74	18.12 ± 1.32**	16.13 ± 0.67	17.03 ± 0.71***
		J/H ratio		1.30 ± 0.11	1.23 ± 0.14	1.36 ± 0.08	1.27 ± 0.10**
				n=43	n=1	n=60	n=3
		I/S ratio		3.78 ± 0.19	4.14	3.86 ± 0.15	3.96 ± 0.12
	non-elite			n=377	n=59	n=443	n=100
		Height	(cm)	153.8 ± 9.1	157.6 ± 9.4**	174.3 ± 6.3	177.4 ± 5.3***
		Body Weight	(kg)	42.8 ± 8.8	49.7 ± 12.9***	65.0 ± 8.2	71.0 ± 11.8***
		30m Straight Sprint	(sec.)	4.91 ± 0.36	5.06 ± 0.46*	4.31 ± 0.22	4.48 ± 0.27***
		Standing Long Jump	(cm)	197.7 ± 18.9	193.1 ± 22.0	237.2 ± 16.5	229.9 ± 18.2***
		Ball Throw	(m)	25.0 ± 4.5	24.6 ± 4.7	36.2 ± 4.5	32.6 ± 4.8***
		Illinois Agiliy Test	(sec.)	17.86 ± 1.10	18.38 ± 1.35**	16.35 ± 0.72	16.96 ± 0.86***
		J/H ratio		1.29 ± 0.10	1.23 ± 0.12***	1.36 ± 0.10	1.30 ± 0.11***
				n=93	n=13	n=252	n=35
		I/S ratio		3.81 ± 0.19	3.79 ± 0.18	3.88 ± 0.17	3.92 ± 0.15
female	elite			n=82	n=10	n=85	n=14
		Height	(cm)	159.3 ± 5.7	159.2 ± 3.9	165.1 ± 165.1	169.3 ± 2.7**
		Body Weight	(kg)	46.6 ± 5.1	45.4 ± 4.7	55.1 ± 55.1	60.5 ± 6.0**
		30m Straight Sprint	(sec.)	4.81 ± 0.27	5.01 ± 0.24*	4.70 ± 4.70	4.84 ± 0.27
		Standing Long Jump	(cm)	195.5 ± 13.2	196.1 ± 10.2	204.8 ± 204.8	193.9 ± 15.2*
		Ball Throw	(m)	23.9 ± 2.8	21.2 ± 4.2*	27.6 ± 27.6	24.8 ± 2.4**
		Illinois Agiliy Test	(sec.)	17.69 ± 0.71	18.39 ± 0.61**	17.33 ± 17.33	18.27 ± 1.17**
		J/H ratio		1.23 ± 0.09	1.23 ± 0.05	1.24 ± 1.24	1.15 ± 0.10**
				n=55	n=5	n=67	n=9
		I/S ratio		3.75 ± 0.20	3.78 ± 0.08	3.74 ± 3.74	3.82 ± 0.19
	non-elite			n=373	n=52	n=435	n=71
		Height	(cm)	152.3 ± 8.8	156.1 ± 6.1**	161.5 ± 5.2	165.1 ± 4.9***
		Body Weight	(kg)	42.2 ± 7.1	47.5 ± 7.7***	53.9 ± 6.1	57.3 ± 6.3***
		30m Straight Sprint	(sec.)	5.08 ± 0.32	5.26 ± 0.36***	4.80 ± 0.24	5.02 ± 0.42***
		Standing Long Jump	(cm)	185.1 ± 15.1	179.3 ± 16.2*	198.2 ± 13.8	194.6 ± 18.8*
		Ball Throw	(m)	20.1 ± 3.7	19.3 ± 3.7	24.8 ± 3.2	22.9 ± 3.0***
		Illinois Agiliy Test	(sec.)	18.54 ± 1.02	19.35 ± 1.21***	17.64 ± 0.78	18.60 ± 1.36***
		J/H ratio		1.22 ± 0.16	1.15 ± 0.10***	1.23 ± 0.09	1.18 ± 0.12***
				n=138	n=30	n=248	n=21
		I/S ratio		3.75 ± 0.17	3.77 ± 0.18	3.75 ± 0.15	3.86 ± 0.23**

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Note: elite = the group consisted of the subjects selected for the higher category after the training camp;
non-elite = the rest of the subjects

during practices/games in player selection. However, it has been suggested that the necessary elements for goalkeeper are intelligence, courage, good physical condition and above all physically fit (Adrian S., 2020). The assessment of physical fitness would be still important to evaluate the potentials of goalkeeper.

Table4. Physical fitness characteristics of elite players compared to non-elite players

sex	positions	variables		U13 (school grade: under 7th)		U16 (school grade: 8th-11th)	
				elite	non-elite	elite	non-elite
male	court players			n=76	n=377	n=84	n=443
		Height	(cm)	164.0 ± 9.2	153.8 ± 9.1***	178.5 ± 5.5	174.3 ± 6.3***
		Body Weight	(kg)	52.0 ± 9.0	42.8 ± 8.8***	67.5 ± 7.9	65.0 ± 8.2*
		30m Straight Sprint	(sec.)	4.65 ± 0.29	4.91 ± 0.36***	4.26 ± 0.18	4.31 ± 0.22*
		Standing Long Jump	(cm)	213.2 ± 20.4	197.7 ± 18.9***	243.4 ± 14.3	237.2 ± 16.5***
		Ball Throw	(m)	30.7 ± 4.5	25.0 ± 4.5***	39.2 ± 4.5	36.2 ± 4.5***
		Illinois Agiliy Test	(sec.)	17.08 ± 0.74	17.86 ± 1.10***	16.13 ± 0.67	16.35 ± 0.72**
		J/H ratio		1.30 ± 0.11	1.29 ± 0.10	1.36 ± 0.08	1.36 ± 0.10
				n=43	n=93	n=60	n=252
		I/S ratio		3.78 ± 0.19	3.81 ± 0.19	3.86 ± 0.15	3.88 ± 0.17
	goal keepers			n=12	n=59	n=12	n=100
		Height	(cm)	165.6 ± 6.9	157.6 ± 9.4**	183.3 ± 4.7	177.4 ± 5.3***
		Body Weight	(kg)	57.0 ± 13.8	49.7 ± 12.9	79.0 ± 7.8	71.0 ± 11.8**
		30m Straight Sprint	(sec.)	4.93 ± 0.32	5.06 ± 0.46	4.47 ± 0.17	4.48 ± 0.27
		Standing Long Jump	(cm)	203.6 ± 26.8	193.1 ± 22.0	232.3 ± 13.8	229.9 ± 18.2
		Ball Throw	(m)	29.5 ± 3.3	24.6 ± 4.7**	36.6 ± 4.0	32.6 ± 4.8**
		Illinois Agiliy Test	(sec.)	18.12 ± 1.32	18.38 ± 1.35	17.03 ± 0.71	16.96 ± 0.86
		J/H ratio		1.23 ± 0.14	1.23 ± 0.12	1.27 ± 0.10	1.30 ± 0.11
				n=1	n=13	n=3	n=35
		I/S ratio		4.14	3.79 ± 0.18	3.96 ± 0.12	3.92 ± 0.15
female	court players			n=82	n=373	n=85	n=435
		Height	(cm)	159.3 ± 5.7	152.3 ± 8.8***	165.1 ± 165.1	161.5 ± 5.2***
		Body Weight	(kg)	46.6 ± 5.1	42.2 ± 7.1***	55.1 ± 55.1	53.9 ± 6.1*
		30m Straight Sprint	(sec.)	4.81 ± 0.27	5.08 ± 0.32***	4.70 ± 4.70	4.80 ± 0.24***
		Standing Long Jump	(cm)	195.5 ± 13.2	185.1 ± 15.1***	204.8 ± 204.8	198.2 ± 13.8***
		Ball Throw	(m)	23.9 ± 2.8	20.1 ± 3.7***	27.6 ± 27.6	24.8 ± 3.2***
		Illinois Agiliy Test	(sec.)	17.69 ± 0.71	18.54 ± 1.02***	17.33 ± 17.33	17.64 ± 0.78**
		J/H ratio		1.23 ± 0.09	1.22 ± 0.16	1.24 ± 1.24	1.23 ± 0.09
				n=55	n=138	n=67	n=248
		I/S ratio		3.75 ± 0.20	3.75 ± 0.17	3.74 ± 3.74	3.75 ± 0.15
	goal keepers			n=10	n=52	n=14	n=71
		Height	(cm)	159.2 ± 3.9	156.1 ± 6.1	169.3 ± 2.7	165.1 ± 4.9**
		Body Weight	(kg)	45.4 ± 4.7	47.5 ± 7.7	60.5 ± 6.0	57.3 ± 6.3
		30m Straight Sprint	(sec.)	5.01 ± 0.24	5.26 ± 0.36*	4.84 ± 0.27	5.02 ± 0.42
		Standing Long Jump	(cm)	196.1 ± 10.2	179.3 ± 16.2**	193.9 ± 15.2	194.6 ± 18.8
		Ball Throw	(m)	21.2 ± 4.2	19.3 ± 3.7	24.8 ± 2.4	22.9 ± 3.0*
		Illinois Agiliy Test	(sec.)	18.39 ± 0.61	19.35 ± 1.21*	18.27 ± 1.17	18.60 ± 1.36
		J/H ratio		1.23 ± 0.05	1.15 ± 0.10*	1.15 ± 0.10	1.18 ± 0.12
				n=5	n=30	n=9	n=21
		I/S ratio		3.78 ± 0.08	3.77 ± 0.18	3.82 ± 0.19	3.86 ± 0.23

$^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$

Conclusion

The results of the present study found the anthropometric and fitness characteristics of Japanese adolescent handball players. It would be necessary to conduct the physical fitness test in older age categories and further longitudinal research to demonstrate adolescent players the required physical fitness levels.

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HOW FEEDBACK AFFECTS THROWING SPEED AND ACCURACY AS A FUNCTION OF HANDBALL PLAYERS' EXPERIENCE LEVEL

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Summary

The porpose of this work is focused of the effect that feedback has on performance in a throwing task (speed and accuracy). Thyrty-five college students without previous experience in the task, and thirty nine expert women handball players participated in this study. Both groups were randomly assigned to tree experimental conditions (positive, negative, an lack of feedback). Throwing speed and accuracy were assessed.

1. Introduction

The provision of information to encourage athletes to continue progressing in the execution of tasks is among the various responsibilities that a coach assumes. The impact of feedback on both performance and motor learning is no longer looked at solely as a means of improving performance.

Studies related to a coach's feedback and behavior have shown that training conditions which induce positive feelings related to participants' outcomes can increase perceived competence and self-efficacy as well as performance and motor learning [1-3]. In a study by Schunk & Cox [4] participants' actual performance had no relevance on the feedback that they received. The results revealed that feedback has a strong impact on self-efficacy beliefs. The study by Badami, VaezMousadi, Wulf & Namazizadeh [5], which provides feedback on accuracy of golf putting trials to a group of university students, indicated that feedback regarding the accuracy of their trials resulted in more effective learning as well as increased self-confidence. However, it is important to mention all the participants in this study presented higher levels of experience.

Positive feedback is identified by coaches' expressions emphasizing what has been done well throughout the task or those which praise or encourage athletes. Several studies including non-expert participants have explored the role of positive and negative feedback in sports tasks [6,7].

Positive feedback seems to be related to higher levels of intrinsic motivation and perceived competence [8-10]. In addition, several theories of motivation suggest that positive feedback is more effective in motivating oneself to pursue goals than is negative feedback, because it increases the expectation of reaching the goal and of an athlete's self-efficacy [8,11,12]. In the research by Krenn, Würth, & Hergovich [13], the type of feedback (positive or negative) did not influence the participant's performance, although it did influence their goal setting. In this study, participants given positive feedback set higher goals for themselves compared to participants who were given negative feedback.

2. Materials and Methods

2.1 Procedure

Participants warmed up before the test. To measure the maximum throwing speed, each participant performed five standing maximal throws on the goal without any instructions as to accuracy, and with one minute of rest between each throw. The throw with the highest speed was then selected from the five attempts. Participants were randomly assigned to three groups: positive feedback, negative feedback and or no feedback. The instruction given to the participants was to throw as fast and precisely as possible. Positive and negative feedback groups were not given any type of feedback until trial number 5. The non-feedback group performed 30 pitches respecting the same time intervals, but without receiving any information throughout the task. Participants in the positive and negative feedback groups were given information every five trials, regardless of their actual performance.

2.2 Measures

Throw speed.

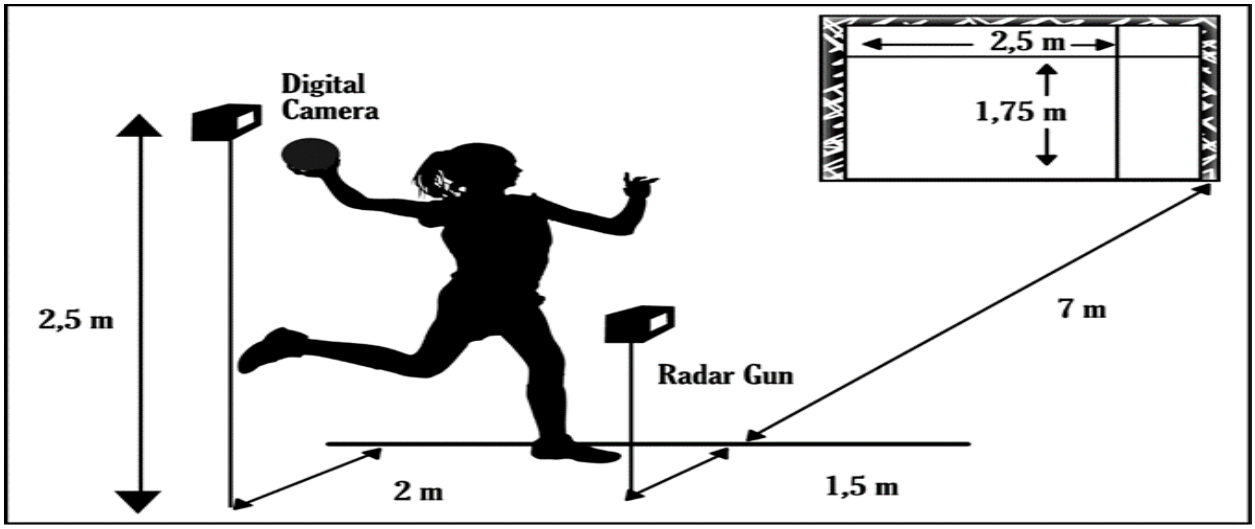
To measure throw speed, the average maximum speed percentage was calculated by averaging the value of ten pitches. To calculate this percentage, the absolute value of the velocity t in km / h of each participant's throw was divided by their maximum throwing speed, and then multiplying the result by 100.To measure individual's' maximum throwing speed, each participant performed five standing maximal throws on the goal without any instruction as to the accuracy and with one minute of rest between each throw. The throw with the highest speed was chosen out of the five attempts.

Finally, the percentage of performance in relation to maximum throwing speed was utilized to measure this variable. A radar gun was obtained from Sports Radar Ltd. (model SR 3600) to measure throwing speed.

Throw accuracy.

A digital Panasonic SDR-H80 (Panasonic Corp., Osaka, Japan) camera was placed opposite the goal at 9 m from the goal line and at a height of 2.5 m. The center of the ball as it entered the goal was digitalized by the computer software "Kinovea©", which identified the deviation of throws with respect to the goal. The points at which the ball entered the goal were indicated digitally, and the coordinates of the real position were calculated (for deviation in both the X and Y axis) by taking the goal dimensions as a reference. The mean radial error (MRE), as described by Hancock, Butler, and Fischman [14], were used to measure the throw accuracy. The mean radial error was measured as the average of the absolute distance to the center of the target.

Figure 1. Graphical representation of the ball throwing task.



2.3 Statistical analyses

An α-level of .05 was employed for all the analyses. Violations of normality and variance homogeneity in all repeated measures ANOVA models, the small sample size, and the use of ordinal Likert-type scales data, required a non-parametric approach [15-16] using an f1-ld-f1 function in the software package 'nparLD' [17] included in 'R 3.5.2'.
In the case of significant interaction effect (feedback*time of measure), post hoc Tukey contrast effects of psychological variables and performance between the three types of feedback for each time of measure were calculated using the function nparcomp of the Rpackage 'nparcomp'[18]. Post hoc pairwise comparisons between the different times of measure for each type of feedback group was tested using a nonparametric studentized permutation analysis with 10000 repetitions (function npar.t.test.paired of the R package 'nparcomp') and a Bonferroni correction for multiple comparisons (the observed p-values for each comparison were multiplied by the number of comparisons). At last, Cliff's Delta was used to measure the nonparametric effect size of pairwise comparisons using the R package 'effsize' [19].

3. Results

Expert Players

The interaction feedback*time of measure (1-10 pitches, 11-20 pitches, and 21-30 pitches) was found significant for throwing speed. Participants who received negative feedback showed higher levels of throwing speed at 11-20 and 21-30 pitches than at 1-10 pitches, meanwhile no differences were found in the other feedback groups (see Table 1).

Likewise, time main effects were determined for throwing speed and feedback main effects for throwing accuracy. On one hand, independent of the type of feedback received, throwing speed was higher at 11-20 pitches ($p < .01$) and 21-30 pitches ($p < .001$) than 1-10 pitches. On the other

hand, independent of the set of pitches, positive feedback group showed a higher accuracy than the negative ($p < .01$) and the no feedback ($p < .01$) groups.

Table 1. Non-parametric repeated measures ANOVA-type models of performance variables for each type of feedback, time of measure and their interaction, and post-hoc comparisons and Cliff's Delta effect size.

Performance Variables	Feedback	Time	Feedb*Time	Post-hoc comparisons for significant interactions (Cliff's Delta[b])					
	F (df^a)	F (df^a)	F (df^a)	No Feedb. f_0	Negative Feedb. f_-	Positive Feedb. f_+	1-10 pitches[c] t_0	11-20 pitches. t_1	21-30 piches t_2
Throw Speed	0.29 (1.98)	11.48*** (1.83)	3.06* (3.42)	$t_0=t_1$ (-.25, S) $t_1=t_2$ (.14, N) $t_0=t_2$ (.21, S)	$t_0<t_1$ (-.57, L)*** $t_1=t_2$ (-.15, S) $t_0<t_2$ (-.64, L)***	$t_0=t_1$ (-.02, N) $t_1=t_2$ (-.21, S) $t_0=t_2$ (-.16, S)	$f_0=f_-$ (-.23, S) $f_0=f_+$ (-.02, N) $f_-=f_+$ (-.30, S)	$f_0=f_-$ (.15, S) $f_0=f_+$ (.08, N) $f_-=f_+$ (.10, N)	$f_0=f_-$ (.28, S) $f_0<f_+$ (-.30, S) $f_-<f_+$ (.12, N)
Throw Accuracy	4.19* (1.82)	0.41 (1.87)	2.10 (3.44)						

Non-Expert Players

Time effects were determined for throwing accuracy and autonomous motivation. In the case of throw accuracy, participants showed higher levels of accuracy at 21–30 pitches than at 1–10 pitches, independent of the type of feedback received. The interaction time of measure×feedback was statistically significant for all the variables except for that of throwing accuracy. At last, regarding performance variables, between group post-hoc comparisons found that those who received positive feedback showed higher levels of throwing speed than those who received negative or no feedback at 21–30 pitches, whereas no differences were found among the previous sets (see Table 2).

Table 2. Nonparametric repeated measures ANOVA-type models of performance variables for each type of feedback, time of measure and their interaction, and post-hoc comparisons and Cliff's delta effect size.

	Feedback	Time	Feedb*Time	Post-hoc comparisons for significant interactions (Cliff's Delta[b])					
Performance Variables	F (df[a])	F (df[a])	F (df[a])	No Feedb. f_0	Negative Feedb. f-	Positive Feedb. f_+	1–10 pitches[c] t_0	11–20 pitches. t_1	21–30 piches t_2
Throw Speed	2.51 (1.96)	0.18 (1.86)	2.98* (3.22)	$t_0 = t_1$ (–.08, N) $t_1 = t_2$ (.31, S) $t_0 = t_2$ (.31, S)	$t_0 = t_1$ (.17, S) $t_1 = t_2$ (.01, N) $t_0 = t_2$ (.21, S)	$t_0 = t_1$ (–.04, S) $t_1 = t_2$ (–.26, S) $t_0 = t_2$ (–.22, S)	$f_0 = f$- (–.11, N) $f_0 = f_+$ (–.12, N) f- = f_+ (–.15, S)	$f_0 = f$- (–.44, M) $f_0 = f_+$ (–.08, N) f- = f_+ (–.41, M)	$f_0 = f$- (–.38, M) $f_0 < f_+$ (–.56, L)* f-<f_+ (–.71, L) *
Throw Accuracy	0.55 (1.92)	6.27* (1.95)	1.27 (3.32)						

Note. α-level is set at .05; *p< .05.

[a] The denominator of all df values is ∞; e.g. 1.96, ∞.

[b] Cliff's Delta interpretation: N = negligible, S = small, M = medium, L = large.

4. Discussion

The results found in our work are not consistent with these previous findings given that there were no changes in perceived competence due to the type of feedback received. It is possible that the effect of feedback may be moderated by the athletes' experience and/or performance level. On the other hand, social comparisons allow people to obtain information regarding their ability in relation to others. For Cheng and Lam [20], such social comparisons are a means of self-evaluation and of the development of self-concept.

With respect to performance variables (throwing speed and accuracy), those who received negative feedback showed a higher throwing speed are coincident [21]. No diferences in throwing accuracy were found due to feedback. These findings not only dier from studies in which inexperienced participants who received negative feedback performed no worse than those who received positive feedback [22], but also from other studies such as Saemi [7] or Ávila [8], in which the positive feedback group in the retention test demonstrated greater accuracy in a throwing task.

Non-expert players involving the use of social comparative feedback with inexperienced participants observed throwing speed and accuracy, the results show that in the last set of pitches (21–30) the positive feedback group pitched the ball at a faster rate than did the other two groups. These results differ from those found in other studies in which the participants subjected to negative feedback did not perform any worse than those subjected to positive feedback [23].

5. Conclusions

In light of the results lead to the conclusion that the feedback provided to an expert player does not have the same effect as that provided to a non-expert player.

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EFFECTS OF COVID-19 PANDEMIC, ON MAXIMUM AEROBIC CAPACITY AND 30-15 INTERMITTENT FITNESS TEST PERFORMANCE; IN PROFESSIONAL FEMALE HANDBALL PLAYERS

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Abstract: The first purpose of the present study was to identify the possible effects of isolation caused by the COVID-19 pandemic on maximum running speed (V_{IFT}) and the maximum aerobic capacity (VO_{2max}) in female handball, using the 30-15 Intermittent Fitness Test ($30–15_{IFT}$). The second purpose was to compare the results obtained by the players before and after the home isolation, period of time in which the training took place under unsuitable training conditions. The recorded data show a decrease in the average of the maximum level achieved in running between the two tests, as by -0.68 km/h (-3.83%), from 18.43 to 17.75 km/h. The reached level at exhaustion varies between 17 and 19.5 km/h in pre-isolation and between 16 and 18.5 km/h after the isolation. Regarding VO_{2max}, the maximum aerobic power decreased by -0.9 (-3.85%), from 54.58 $mlkg^{-1}min^{-1}$ when tested before the isolation to 48.53 $mlkg^{-1}min^{-1}$ after the isolation. According to the non-parametric Wilcoxon test, the difference reached the threshold of statistical significance, z = -3.297, p = 0.001 < 0.05, with a large effect size (r=0.59) for the maximum running speed and z = -3.384, p = 0.001 < 0.05, with a large effect size (r=0.58) for the VO_{2max}, indicating a statistically significant mean decrease in physical and physiological capacity of the players, after the lockdown caused by the Covid-19 pandemic.

Keywords: maximum aerobic capacity; female handball players; COVID-19 pandemic

1. Introduction

In March 2020, the World Health Organization declared the new coronavirus (SARS-CoV2 or COVID-19), the cause of an unprecedented pandemic [1] and urged governments from all around the world to "urgent and aggressive actions" in order to delay and decrease the infection [2]. However, the COVID-19 virus, which existed already since December 2019 in Wuhan China, spread very quickly at a global level, throwing the world in the middle of a crisis with many effects in all areas of activity.

Thus, for the first time in history, it was a worldwide timeout for all sports. As a result, all the competitions were suspended, the common trainings were forbidden and the athletes were obliged to quarantine at home like the rest of the population. The health of the athletes, coaches and spectators has become primordial. The Tokyo Olympics have been postponed for the summer of 2021 [3], a situation that has never been seen in the history of world sport. Other major sports

competitions, such as the European Football Championship, the European Women's Handball Championship, etc., were scheduled for other dates [4], this kind of situation being encountered the last time in the Second World War.

On 16 March 2020, the State of Emergency was established on the territory of Romania for 30 days, caused by the COVID-19 pandemic, which was subsequently extended until 15 May 2020, after which the State of Alert was settled.

At the beginning of quarantine, all mankind experienced unusual living situations imposed both by restrictive rules in order to protect public health and for fear of the unknown and the danger of the new virus, aspects which led to imbalances in all aspects of social life. One of these was at the level of physical activity. Home isolation involved the limitation and even complete disappearance of outdoor movement in order to reduce the risk of infection.

In performance sport, the training of athletes under normal conditions has become impossible and thus the need to continue training has been raised, according to individual plans, adapted to the period of the current competition season, in order to make possible re-evaluation of the activity. Coaches were forced to submit individual training protocols tailored to the needs of the athletes and the training conditions they had at their home. Normally, the transitional period must assure the link between two preparatory macrocycles, while ensuring the overcompensation phase for the next phase of effort. In order to continuously improve the performance, athletes must be able to start a new high-level training cycle, and the complete rest, free of any form of physical activity, is the wrong approach, even under conditions of major force, as the imposed situation by the pandemic caused by COVID-19. More than that, maintaining physical capacity is a crucial requirement for professional players, because physiological adaptations are reversible and physical accumulations could be lost in 2-4 weeks when sportsmen stop training [5]. It is suggested that time off training and competitions should also be used for other purposes too, such as goal setting or psychological development [6] based on different tests or pedagogical experiments, implemented in an attempt to acquire new knowledge, by players with different levels of memory development [7]. Recent studies [8, 9] talk about the need for continuity in sports training, so that the effort capacity of athletes is maintained at about 60-70% of the maximum possibilities, even in the seasons breaks.

The implementation and monitoring of the sports training program in isolation regarding the team subject to our study, has mainly followed up the accommodation and improvement in energetic and control parameters [10] of the muscles, tendons and ligaments for the new training plan through individual development programs for general force and articular mobility. Although the effort during matches and handball training is mainly anaerobic and includes actions such as throwing, jumping, accelerations, changes in direction, duels and physical contacts, both on the counterattack, positional and defensive phases [9], the importance of aerobic capacity should not be underestimated.

In this context, the first purpose of the present study was to identify the possible effects of isolation caused by the COVID-19 pandemic on the maximum aerobic capacity in female handball players. The second purpose was to compare the results obtained before and after the home isolation, period of time in which the training took place under unsuitable training conditions.

2. Materials and Methods

2.1. Subjects

Our sample of subjects were sixteen well trained healthy female handball players of CSM Galați (28.2 ± 6.1 years, 173.1± 5.8 cm, and 66.3 ± 6.9 kg), who during the 2019/20 season participated in the second division competition, in Romania. Handball leagues competitions were suspended on 11th of March by the Sports Ministry and home exercises started on 4th of April. The players underwent a period of two months (63 days) of individual training in isolation, by respecting the protocols sent by the coach through internet means. Because players had little and inadequate space for training at home, the protocols were based mainly on developing physical capacity, by the use of body weight exercises.

30-15 Intermittent Fitness Test (*30–15$_{IFT}$*) was applied, in order to evaluate *VO$_{2max}$* capacity, when the team returned to collective trainings, on 6th of June and these results were then compared to the ones from February 2020 (players have this test twice a year for monitoring the physical capacity).

All subjects were familiar with field exercise evaluation and were tested, on both occasions, on a wooden indoor floor (temperature 22°C).

2.2. Experimental Approach to the Problem

In order to an accurate evaluation regarding the conducting matches conditions, it is recommended the use of tests which require physiological responses and field movements similar to those during the game. Because the effort in the handball game is discontinuous with maximal, submaximal and medium alternations, the 30-15 Intermittent Fitness Test (*30–15$_{IFT}$*), an intermittent and shuttle incremental field test, is recommended. The *30–15$_{IFT}$* shown to be accurate for individualizing intermittent and shuttle running exercise [11] and was first validated in 2005 [12]. Since its appearance, the author has published numerous articles related to it and was validated in other sports too [13, 14, 15].

The test protocol consists of 30-s shuttle runs interspersed with 15-s passive recovery periods and the initial velocity is 8 km/h and grows by 0.5 km/h with every repetition. Sound signals dictate the velocity and players run until they are unable to keep up with it. The test is completed when they are unable to reach the selected line on the court three consecutive times (or 3 m of the tolerance zone in front of the line). The velocity attained during the last completed stage is determined as the player's *V$_{IFT}$*, and then one can estimate *VO$_{2max}$*.

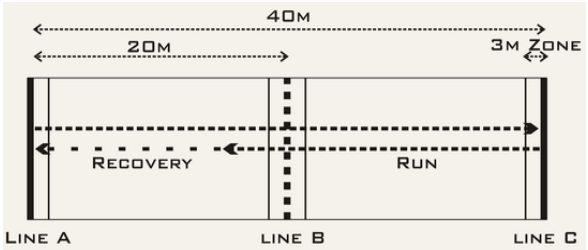

Figure 1. Schematic representation of the 30-15IFT procedure.

To calculate the VO_{2max} for each player we used the following formula:

$$VO_{2max}(ml \cdot kg^{-1} \cdot min^{-1}) = 28.3 - 2.15 \cdot G - 0.741 \cdot A - 0.0357 \cdot W + 0.0586 \cdot A \cdot W \cdot V_{IFT} + 1.03 \cdot V_{IFT} \quad (1)$$

In equation 1, V_{IFT} (velocity – intermittent fitness test) is the final running speed, *G* stands for gender (female = 2; male = 1), *A* for age, and *W* for weight [16].

2.3. Statistical analysis

We calculated the means, minimum, maximum, progress and standard deviations for maximum running speed (V_{IFT}) and maximum aerobic capacity (VO_{2max}) before and after isolation. The Shapiro-Wilk test (S-W) was used to verify the normality of distribution. Results showed that data were not normally distributed ($p < 0.05$). The non-parametric Wilcoxon signed-rank test was used in order to understand whether there was a significant difference in results for maximum velocity speed and maximum aerobic capacity, before and after isolation. We also calculated the effect size measure for the non-parametric analysis. We defined the effect size ES = Z/√N, a formula proposed by Rosenthal [17] where *Z* is derived from the *z*-score of the Wilcoxon test and N is the total number of observations. Cohen's criteria [18] was considered, which indicates r = 0.1 as small effect, r = 0.3 as medium effect and r = 0.5 as large effect. Statistical analysis was performed using IBM SPSS Statistics for Macintosh, Version 25 (IBM Corp., Armonk, N.Y., USA) and $p < 0.05$ was taken for the significance differences.

3. Results

Regarding Table 1, from the total number of players (n=16) included in the research, we see a decrease in the maximum level reached in running, with only two players able to register the same level in both tests. All the other players registered a lower level to that made before the isolation. After obtaining all the data related to $\boldsymbol{V_{IFT}}$ **(**maximum level of running), we applied the necessary mathematic formula for calculating the $\boldsymbol{VO_{2max}}$ (maximum aerobic capacity) for each player.

Table 1. Player's anthropometric measures and results for *30-15 IFT* and *VO2max*.

Players	Anthropometric measures			V_{IFT} (km/h)		VO_{2max} ($ml \cdot kg^{-1} \cdot min^{-1}$)	
	Gender	Age (years)	Weight (kg)	Before Isolation	After Isolation	Before Isolation	After Isolation
Player 1	2	26	66	18.5	18	49,62	48,56
Player 2	2	36	63	18	17.5	51,6	50,55
Player 3	2	30	63	19.5	18.5	53,89	51,1
Player 4	2	38	65	18.5	18	53,8	52,15
Player 5	2	33	65	19	18.5	53,54	52,05
Player 6	2	30	62	19	18	54,53	51,74
Player 7	2	30	83	18	18	48,99	48,99
Player 8	2	34	66	18	16	50,86	45,75
Player 9	2	25	66	18.5	18.5	49,28	49,28
Player 10	2	32	70	18.5	17.5	51,54	48,63

Player 11	2	26	60	19	18	51,11	48,56
Player 12	2	32	66	19.5	18.5	54,58	51,68
Player 13	2	19	80	17	16	43,51	41,37
Player 14	2	19	58	17.5	17	45,36	44,29
Player 15	2	18	71	17	16.5	43,58	42,53
Player 16	2	24	58	19	18.5	50,52	49,09

Table 2 presents the descriptive statistic data obtained for both maximum running speed (V_{IFT}) and maximum aerobic capacity (VO_{2max}). We can observe a decrease in the average of the maximum level reached in running of 0.68 km/h (-3.83%), from 18.43 km/h to 17.75 km/h in between tests. The level reached at exhaustion varies between 17 and 19.5 km/h in pre-isolation test and between 16 and 18.5 km/h after isolation. Concerning VO_{2max}, the maximum aerobic power decreased by 1.87 (ml kg^{-1} min^{-1}) (-3.85%), from 54.58 in pre-isolation testing to 48.53 (ml kg^{-1} min^{-1}), after isolation.

Table 2. Descriptive statistics for *30-15*$_{IFT}$ and VO_{2max}.

	N	Minimum	Maximum	Mean		Progress	Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error		Statistic
V_{IFT} Before Isolation	16	17.00	19.50	18.40	0.19	-0.68	0.77
V_{IFT} After Isolation	16	16.00	18.50	17.68	0.20	(-3.83%)	0.87
$VO_{2\ max}$ Before Isolation	16	43.51	54.58	50.39	0.9	-1.87	3.6
$VO_{2\ max}$ After Isolation	16	41.37	52.15	48.52	0.84	(-3.85%)	3.37
Valid N (list wise)	16						

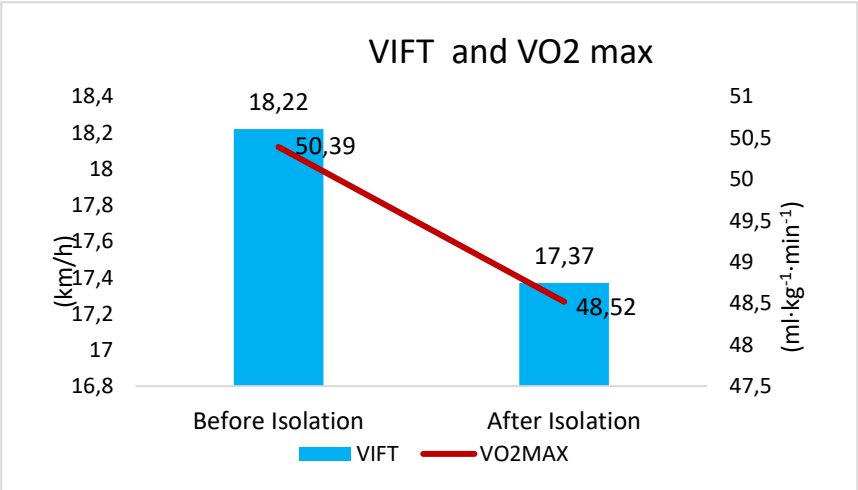

Figure 2. V_{IFT} and $VO_{2\ max}$ before and after isolation.

Figure 2 show the evolution of the maximum aerobic capacity and the maximum velocity calculated by following the *30-15 IFT* test. Players were tested in two separate occasions: before the isolation period, under normal conditions of training organization and in the post-isolation period, after two months of training under improper conditions.

Table 3. Wilcoxon Signed Ranks Test Statistics.

Test Parameters	V_{IFT} Before Isolation – V_{IFT} After Isolation	$VO_{2\ max}$ Before Isolation – $VO_{2\ max}$ After Isolation
Z	-3.372[b]	-3.297[b]
Asymp. Sig. (2-tailed)	.001	.001

[b]Based on positive ranks

According to the Wilcoxon non-parametric test presented in Table 3, it can be observed that both, maximum velocity and maximum aerobic effort capacity decreased statistically significantly at the end of the isolation period, z = -3.384, p = 0.001 <.05, respectively z = -3.297, p = 0.001<.005.

Table 4. Average values of the analysed indicators measured before versus after the isolation period.

	Before Isolation	After Isolation	p-value	Effect Size
V_{IFT} (km/h)	18.43	17.75	0.001	0.59
$VO_{2\ max}$ (ml·kg-1·min-1)	50.39	48.52	0.001	0.58

4. Discussion

As an unprecedented situation, the COVID-19 pandemic has changed the conditions of preparation and competition at the level of all individual sports and team sports. We can list here a number of consequences on the way in which training was organized during isolation [19]:

- lack of training and competitions;
- poor communication between coaches and athletes;
- lack of free movement and adequate exposure to sunlight;
- inadequate training conditions.

Total inactivity, decreased intensity or mishandling training programs, can lead to the decrease and even total loss of physical accumulations over a period of 2-4 weeks, thus, in order to maintain an optimal performance, is essential for an athlete to follow controlled training protocols, based on both aerobic and muscle strength.

Sixteen well trained healthy female handball players of CSM Galați (28.2 ± 6.1 years, 173.1± 5.8 cm, and 66.3 ± 6.9 kg), who during the 2019/20 season participated in the second division competition, in Romania, were tested. The aim of this study was to compare the results in 30-15 Intermittent Fitness Test, before and after the isolation period caused by the Covid-19 virus pandemic, when training took place under unsuitable training conditions. We hypothesised that the imposed quarantine caused by the COVID-19 pandemic, would compromise the maximum

aerobic capacity (VO_{2max}) in female handball players by leading to the partial or total loss of accumulations during the training period. In this study, a significant mean decrease in maximum running speed, on average of 1.3 ± 0.46% was observed after the isolation period. The V_{IFT} (dif. X = -0.68 km/h, p = 0.001 < 0.05) and the $VO_{2\ max}$ (dif. X = -1.87 $mlkg^{-1}min^{-1}$, p = 0.001 < 0.05) supports these claims, recorded data showing significant main effects of home isolation. The level of maximum velocity and maximum aerobic capacity, in 14 out of 16 players showed negative developments.

In order to evaluate if there were any changes in the maximum aerobic capacity as a result of home isolation caused by the Covid-19 pandemic, the Wilcoxon Signed Rank Test revealed a statistically significantly negative change in performance following the improper training conditions at home, z=-3.297, p = 0.001 < 0.05, with a large effect size (r=0.58). Our findings contradict a recent similar study in soccer [20], where the researchers observed no effects in $VO_{2\ max}$ performance in the Yo-Yo test. This may be explained by the different training conditions and protocols of the players and of course by the quarantine length in their case (40 days), which was shorter then in our study (63 days).

5. Conclusions

The COVID-19 pandemic compromised sport industry on many levels: physical, physiological, psychological, nutritional and financial [21]. Moreover, the virus caused illness among the athletes [22], which led to withdrawals from competitions and even temporary loss of financial income.

Taking all these aspects into account, it is advisable for athletes and even coaches to plan ahead their life after sport. One way to do this is by completing their professional knowledge, through conversion programs that improve the quality of their education [23]. The most recent studies state that it is necessary to continue the training during the transition period, thus the players' effort capacity is maintained at approximately 60-70% from the maximum possibilities [24, 25].

The imposed quarantine is a completely new, unknown situation, which can compromise the ability of sports performance by leading to the partial or total loss of accumulations during the training period. The new living situation permitted little outside training, near the house, and mainly indoor practices, which made it difficult to carry out, due to the lack of necessary conditions (space, material facilities, moral support, etc.).

In this context, it can be said that the training protocols at home are not similar to the aerobic and anaerobic ones in the field environment and can have negative effects on maximum aerobic capacity and general physical performance.

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DEVELOPMENT OF GAME ANALYSIS SYETEM USING COMBINED FREE APPS AND TOOLS

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Summary

We aimed to develop a system that can edit video by tagging each scene, automatically generate statistical data by tagging, and share the edited video and statistical data. we were able to developed a sports analysis system that can share video and statistical data in real-time by combining three applications, YouTube Live Streaming, Google Spreadsheet, and Google Data Portal, which can be used by anyone with Internet access.
Key word: notational analysis, video analysis, live analysis

Introduction

In recently, video sharing and statistical data have been used to evaluate players and their play to create training plans in all sports coaching processes. Similar, video sharing and statistical data of events during training and games are analyzed to help for development of the team in handball. Software and tool using video sharing and statistical data for sports analysis are available from many manufacturers. However, they are very expensive for amateurs and glass tools teams. In this study, we have designed a novel system that combines YouTube live Streaming, Google Spreadsheet and Google Data Portal, which can be used by anyone on the Internet for free.

By combined these applications, we aimed to develop a system that can edit video by tagging each scene, automatically generate statistical data by tagging, and share the edited video and statistical data.

Methods

In this study, YouTube Live Streaming was used to view the video, Google Spreadsheet was used to input the descriptive data, and Google Data Portal was used to display the URLs of video sharing and results of statistical data.

About the part of data input

This spreadsheet contains the following sections: 1. the section for defining the variables needed to perform descriptive analysis of the game (columns C to E), 2. the section that sets the start time of the movie and the names of the teams and players (columns H to K), 3. the section for input text for descriptive analysis (columns S to V), 4. the section for adding a timestamp function to YouTube URLs for video sharing (columns S and AV to BD), and 5. the section for calculating statistical data by descriptive analysis (columns BF to DH) (Figure 1).

1. the section for defining the variables needed to perform descriptive analysis of the game (columns C to E)

In this study, in order to conduct descriptive analysis of a handball game, the game phase was classified into four moments: offense, retreat, defense, and fast break, and the descriptive symbols were set as “a”, “r”, “d”, and “f”, respectively.

In order to record various situations such as numerical advantage and disadvantage, at each moment, the situations from the own team's side were classified as numerical disadvantage (-), numerical advantage (+), attack with 7 players (7), and attack with 6 players during a numerical disadvantage attack (6). In addition, fast break were classified into four phases as 1st wave (f1), 2nd wave (f2), 3rd wave (f3) and after goal (ag).

In order to record the shot location, the shots were categorized as wing shot (w), 6m shot (6), pivot shot (pv), break through shot (bt), 9m shot (9), 7m shot (7), and empty shot (e).

The results were classified into ten categories such as goals, saved shots, shots off frame, arm blocks by defender’s, turnovers due to missed passes and/or attacker’s fouls, free throw, two-minute suspensions, penalties, attack interruptions by the attacker himself, and timeouts.

2. the section that sets the start time of the movie and the names of the teams and players (columns H to K)

For the real-time sharing of YouTube videos, which is the originality of this research, we recorded the URLs where the videos were streaming. In addition, YouTube has the function of adding a time stamp by adding the time from the start of the video streaming to the URL. The timestamp function of YouTube can be used by adding the command "&t=" to the YouTube URL and adding the elapsed time from the start of the video after the command. To use this function, we recorded the time in "MovieStartTime" when the video streaming was started. In addition, we set the delay time in "TimeDelayYouTube" to compensate for the video streaming delay since there is about 20-30 second video streaming delay in YouTube live streaming. In addition, the time difference can be set in the "TimeDifference" field if there is a time difference between the arena and the analysis site. At the same time, here, we can set the team and player numbers and names.

3. the section for input text for descriptive analysis (columns S to V)

Columns S to V were used to input the symbols set in columns B to E, respectively. We set the S column to input the moment, the T column to input the situation, the U column to input the shooting position, the V column to input the result, and the W column to input the player's number. By inputting the moment in the S column, the name of the attacking team was shown in the AB column, and the input results in the V column can be checked in the columns AC to AR as well.

4. the section for adding a timestamp function to YouTube URLs for video sharing (columns S and AV to BD)

The current time was get using Google Apps Script (GAS) when moment in column S was input. The code of GAS was as follow.

```
 function onEdit() {
var ss = SpreadsheetApp.getActiveSpreadsheet();
var sh = ss.getActiveSheet();
var range = sh.getActiveRange();
var row = range.getRow();
var col = range.getColumn();

if(col == 19){ // 19 mean col of S
var time = Utilities.formatDate(new Date(), 'Asia/Tokyo', 'hh:mm:ss');
 sh.getRange(row, 17).setValue(time); // 17 mean col of Q
}
 }
```

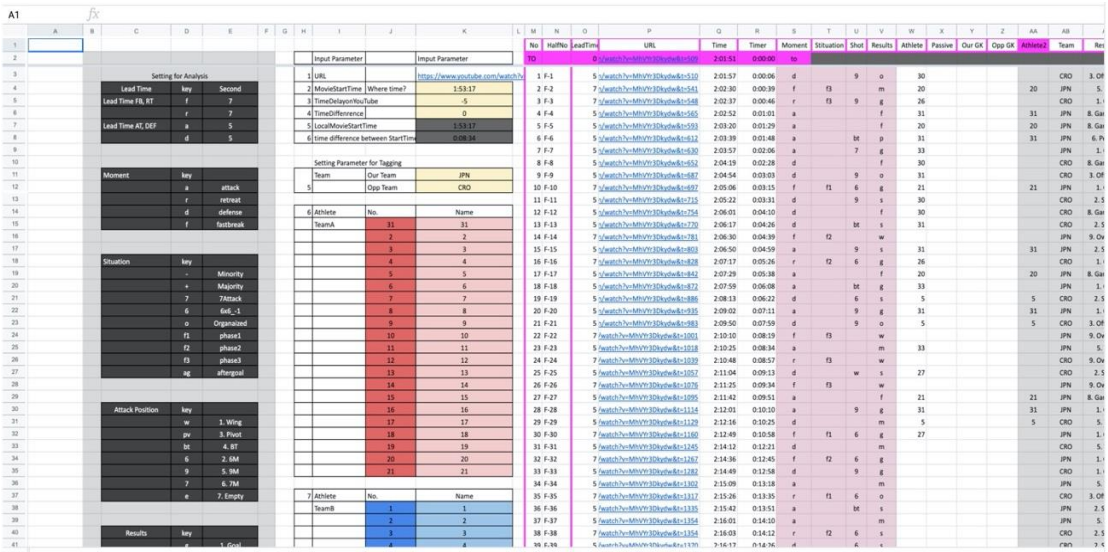

Figure1. Data input sheet

The time difference between the video start time and the current time at the moment input, obtained using GAS, was calculated between the AV and BD columns. Time stamped YouTube URLs were created for each moment input by adding YouTube URL with "&t=" and calculated the time difference between the video start time and the current time at the moment input.

5. the section for calculating statistical data by descriptive analysis (columns BF to DH)

Between columns BF and DH, the inputted data were counted and/or calculated, respectively, in order to demonstrate statistical data in the Google Data Portal.

Data output

Time-stamped YouTube URLs and statistical data created in the Google spreadsheet were displayed using the Google Data Portal (Figure 2). The game pace and number of possessions, shots, and goals scored and the ratio of shots per possession (xS), ratio of goals scored per possession (xG), and shot efficiency by each team were displayed in the upper left of dashboard.

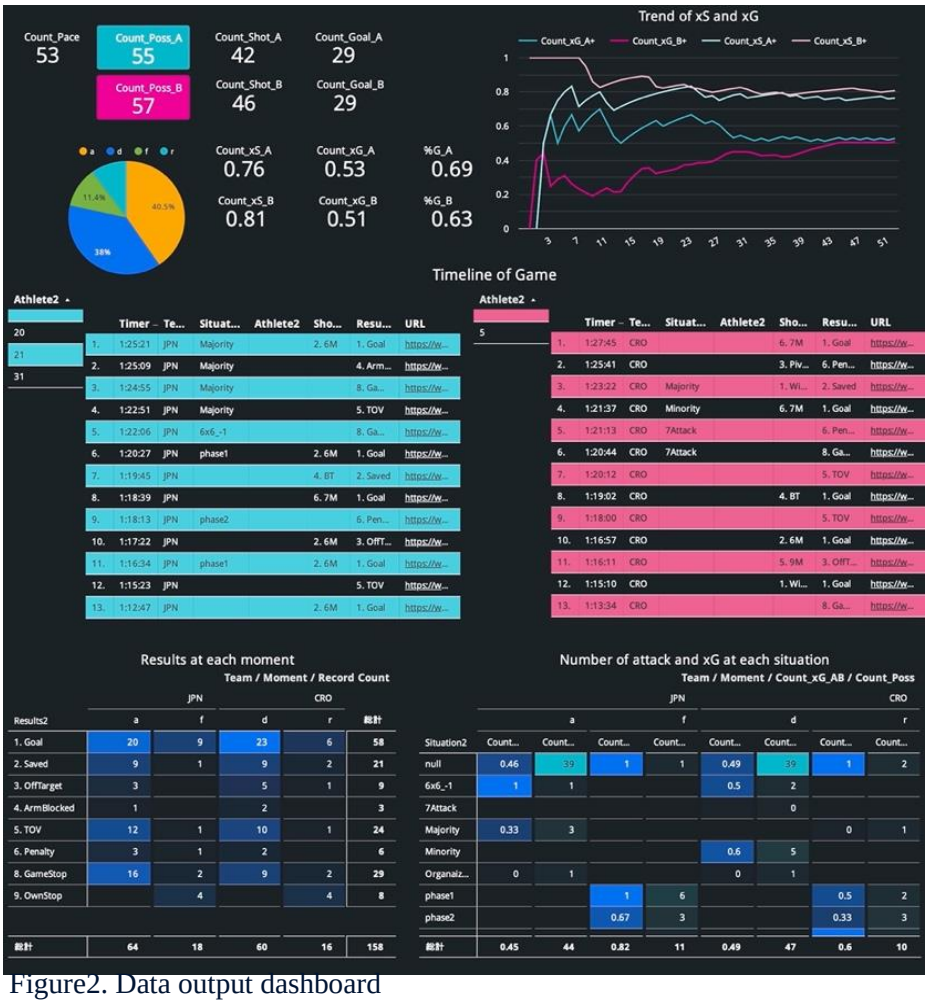

Figure2. Data output dashboard

In the top right, the graph of time series changes in xS and xG of each team was showed. The table in the center shows the timeline of game trends for each team. The URLs to the right in this table shared the video of each scene. In addition, interactive links have been set up in tables and graphs to search the statistical data and videos.

Testing of this system at the Men's World Championships in 2021

In this study, we examined the availability of this system for six of Japan's matches at the 2021 Men's World Championship.

Results

Figures 1 and 2 were showed a Google spreadsheet with the data input about game of the JAPAN against CROATIA and the Google Data Portal with the output of the results. On the Google Data Portal, it become possible to share video classified into moments such as “attack”, “retreats”, “defenses”, and “fast break” for each team. In addition, interactive links allowed users to quickly search for the URLs of the scene they want to watch. The URLs for the data input and output results of the six games analyzed are shown as below.

Discussion

Data input
https://docs.google.com/spreadsheets/d/1AqcUbru5-DdqDr_ddCqJK9UwiA4m5oIfgt6utJNJNmA/edit?usp=sharing

Data output
- JAPAN against CROATIA
  https://datastudio.google.com/reporting/193d7948-fa70-490e-944c-57c758913bfa
- JAPAN against QATAR
  https://datastudio.google.com/reporting/a84dc11c-0165-40f5-b716-d1b0bd2d286e
- JAPAN against ANGOLA
  https://datastudio.google.com/reporting/b27dbd7d-a989-4162-988c-21a15cfad424
- JAPAN against ARGENTINE
  https://datastudio.google.com/reporting/d2f529df-61ca-4d0a-b66f-70682ff5a17e
- JAPAN against DENMARK
  https://datastudio.google.com/reporting/38032fb3-9b55-4dea-a429-68ee1456fcec
- JAPAN against BAHRAIN
  https://datastudio.google.com/reporting/b0b350a3-a815-4d02-8f4f-d45c349e2004

In this study, we were able to developed a sports analysis system that can share video and statistical data in real-time by combining three applications, YouTube Live Streaming, Google Spreadsheet, and Google Data Portal, which can be used by anyone with Internet access. This analysis system has almost the similar functions as commercially supplied sports analysis software to share video and statistical data.

The unique advantage of the system in this study was that data input and output could be operated by different terminals. As a result, multiple terminals can collaborate on data input and output. Furthermore, one of the unique advantage in this system is that the location of the data input and output can be ignored by sharing them over the Internet. To the best of our knowledge, there is no other system that can be used free of charge and can share video and statistical data in real-time around the world.

In this study, we classified the game into 4 game moment, 9 attacking situations, 7 shooting positions, and 10 outcomes to obtain for statistical analysis in handball. In this system, it is possible to flexibly set the variables to be analyzed in 1. the section for defining the variables needed to perform descriptive analysis of the game (columns C to E). As a result, the analysis variables can be set according to the ideas of the team or the analyst. Similar, In the data output, display of variables, table and graph can make to the ideas of the team or the analyst.

This system can be used freely by anyone. Of course, we will plan to create a database of the video and statistical data analyzed for each match in the future. If an open-source sports analysis system like this is developed, a database similar to soccer's like a Wyscout can be created in an

open environment with the cooperation of handball friends around the world. We also believe that handball friends around the world will be able to freely analyze the games and create a database of video and statistical data, which will lead to the further development of handball. And we hope it will.

The three applications from Google used in this system are very useful on the Internet and can be easily linked to several other applications, which is much easier than developing new applications on own. However, this system is fully dependent on Google. Thus, this system contains the risk of becoming unusable due to the modification and/or termination of the services of these applications, which is unavoidable. In addition, this system uses the time stamp function on the video sharing site. Therefore, there is a limitation that only statistical data can be applied in this system on sites where the video publication does not have a time stamp function.

Conclusion

We were able to develop a video sharing and statistical analysis system with functions similar to those of paid sports video and statistical analysis software using combined three applications, such as YouTube Live Streaming, Google Spreadsheet, and Google Data Portal, which can be used by anyone with Internet access.

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DOES REPEATED SHORT-TERM ANAEROBIC MAXIMAL EXERCISE AFFECT THE CENTER OF GRAVITY STABILITY OF HANDBALL PLAYER?

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Keywords: handball, wingate anaerobic test, center of gravity, fatigue

Summary

We investigated the effects of repeated short-term maximal anaerobic exercise on the stability of the center of gravity. It was evident that when the elite handball wing player repeated intermittent high-intensity whole-body exercise, the sway of their center of gravity gradually increased. Instability of the center of gravity due to repeated anaerobic exercises can adversely affect the performance of handball players.

Introduction

In a handball game where all players are involved in attack and defense, the average heart rate during the game reaches 80% to 90% HR max. The specific movements in a handball game are a complex mix of sprinting, high-speed running, physical contact, jumping, landing, and strong and accurate throwing. Consequently, the ability to repeatedly exert anaerobic power is required. It is important to understand the physical effects of repeated high-intensity exercise in sports such as handball, which requires intermittent high-power exertion. One test that can accurately assess the anaerobic exercise capacity of handball players is the Wingate anaerobic test (WAnT). The 30-s submaximal effort pedaling test has been shown to involve a large amount of anaerobic energy, and the percentage of aerobic energy supply in this test has been reported to be around 13-28% (Inbar et al., 1996). In addition, the test does not capture information about a specific muscle group, but rather evaluates the power involved in a systemic muscle group. Conversely, the repetition of high-intensity exercises is predicted to cause acute central and peripheral fatigue (Gonzalo et al., 2017). In particular, acute fatigue immediately after high-intensity exercises may not only impair the player's handball performance but may also cause transient loss of balance at the center of gravity, thus increasing the risk of injury. Previous studies have shown that fatigue increases injury incidence (Frisch et al., 2011) and an impaired balance performance may increase the risk of ankle

injury (Willems et al., 2005). In this study, we investigated the effects of repeated short-term maximal anaerobic exercise on the stability of the center of gravity.

Methods

<Subjects>
Six elite university handball wing players (age, 19.3 years; height, 171.2 ± 3.7 cm; weight, 62.7 ± 5.7 kg) were included. They were players who had been playing handball for five years and training 6 days/week, 3 h/day. Previously, the team won a silver medal in the Japan Intercollegiate Handball Championship. Subjects with pre-existing lower extremity conditions that put them at risk for further injury or with known visual, vestibular, or balance impairments were excluded. As per the Declaration of Helsinki, the purpose and methods of this study were explained to the subjects, and the experiment was conducted after obtaining their consent.

<Experimental Protocol>
Subjects were measured for anthropometry and sprint running (30 m and 50 m) a few weeks before the experiment. On the day of the experiment, after a light warm-up of approximately 10 min, the WAnT was conducted at maximal effort for 30 s and repeated to obtain three sets of results, using a cycle ergometer (POWER MAX V3, KONAMI, JAPAN). The WAnT loading was set at 7.5% of the weight of each subject (Inbar et al., 1996). The rest period between each set was established for 2 min, and a center of gravity balance test (BT; 30-s of dominant one-leg standing with vision) was included. The BT was started 1 min after the end of the WAnT. During the 2-min rest period, the subjects were kept at rest in a standing position, except during the 30-s BT. Overall, a 30-s bicycle exercise under maximal effort and a 2-min rest in the standing position were repeated three times.

<Measurements (WAnT and BT) and Statistical Analysis>
Peak power (PP; w), mean power (MP; w), peak rotations per minute (peak RPM), and peak arrival time (PAT; s) were measured as indices of anaerobic capacity during the 30 s of bicycle exercise. The trajectory length (TL; mm) and sway area (SA; mm^2) of the center of gravity change were measured using a center of gravity trajectory measurement device (TAKEI-KIKI, JAPAN). The obtained results were examined by one-way analysis of variance and multiple comparisons (Bonferroni). Pearson correlation coefficients were used to analyze the correlations between the indices. Statistical significance was set at $p < 0.05$. Statistical analysis was performed at the Universiti Teknologi MARA Sports Clinic (Malaysia).

Results

The mean subject sprint time at 30 m and 50 m was 3.94 ± 0.14 s and 6.20 ± 0.12 s, respectively. There was a very high correlation between sprint time and power exerted during the first WAnT. In particular, the correlation coefficient between the 50 m sprint time and PP per body weight (1st set) was r = -0.911 ($p < 0.01$).

Table 1. Results of the Wingate anaerobic test and Balance test

*TL: trajectory length of the change in the center of gravity, SA: sway area,

**MP: mean power, PP: peak power, RPM: rotations per minute, PAT: peak arrival time

	Balance Test*				Wingate Anaerobic Test**			
	TL (mm)	TL/sec. (mm)	SA (mm^2)		MP (w)	PP (w)	peak RPM (/min)	PAT (sec.)
Pre.	681.15±134.62	22.72±4.46	490.92±165.72					
1st set	882.85±129.94	29.42±4.34	871.32±265.70	1st set	572.0±55.2	706.5±47.9	150.5±9.5	6.7±0.7
2nd set	846.98±119.07	28.25±3.98	883.73±106.65	2nd set	511.7±52.9	660.5±65.6	140.5±8.2	6.1±0.6
3rd set	992.32±224.80	33.10±7.49	1497.58±1182.94	3rd set	464.3±46.5	605.2±62.5	129.0±14.6	6.2±1.4

The anaerobic power output obtained from the WAnT decreased significantly with repeated testing (Table 1 and Fig. 1). Immediately after the third set of the WAnT, the MP was reduced by 18.8% compared to the first set ($p < 0.01$). The rate of decrease in PP was 14.3% lower in the third set than in the first set ($p < 0.05$). The PAT was 6.7 s for the first set of WAnT, but was reduced to approximately 6 s for the second and third sets (Table 1 and Fig. 2).

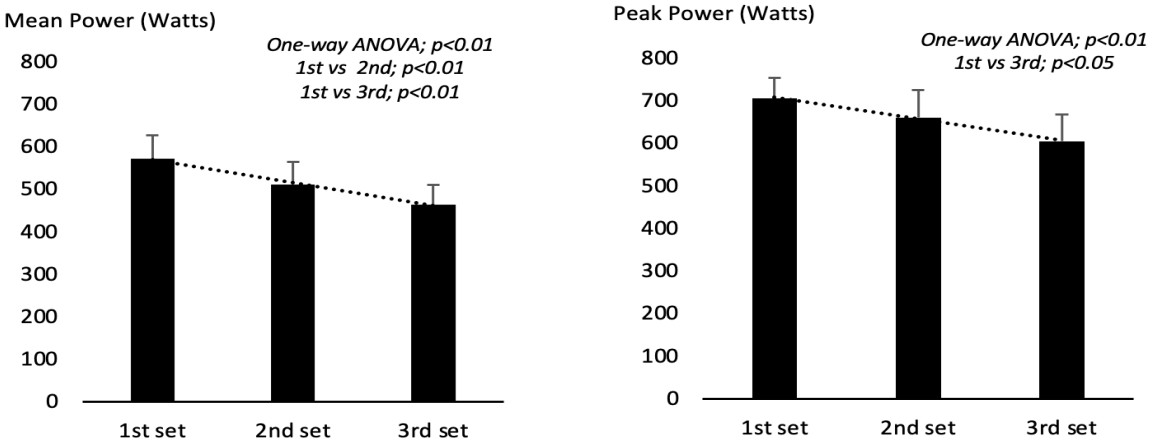

Figure 1. Changes in mean (left fig.) and peak (right fig.) power during the repeated Wingate anaerobic test. A two-minute rest was taken between each test.

Conversely, TL immediately after the WAnT became longer with each repetition (TL: Pre/ 681.15 mm, 1 set/ 882.85 mm, 2 set/ 846.98 mm, 3 set/ 992.32 mm; Fig. 3 left), and the SA also expanded significantly (SA: Pre/ 490.92 mm^2, 1 set/ 871.32 mm^2, 2 set/ 883.73 mm^2, 3 set/ 1497.58 mm^2; Fig. 3 right). The length of the center of gravity trajectory after three sets was extended by 1.47 times compared to the pre-exercise value ($p < 0.05$). The SA of the center of gravity showed a tendency to increase with each WAnT, but the increase was not statistically significant ($p = 0.06$). After three sets, the SA of the center of gravity showed approximately a threefold expansion compared to the pre-exercise value.

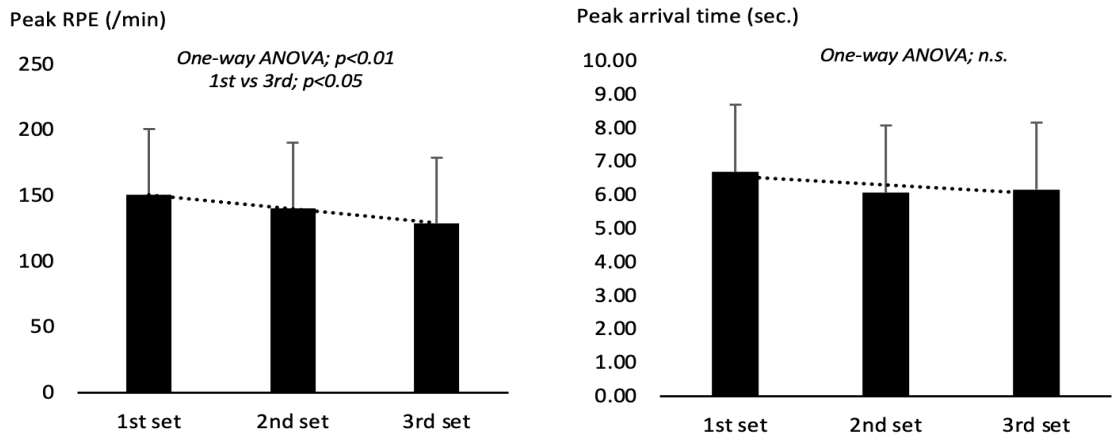

Figure 2. Changes in peak RPE (left fig.) and peak arrival time (right fig.) during the repeated Wingate anaerobic test. There was no statistically significant change in the peak arrival time.

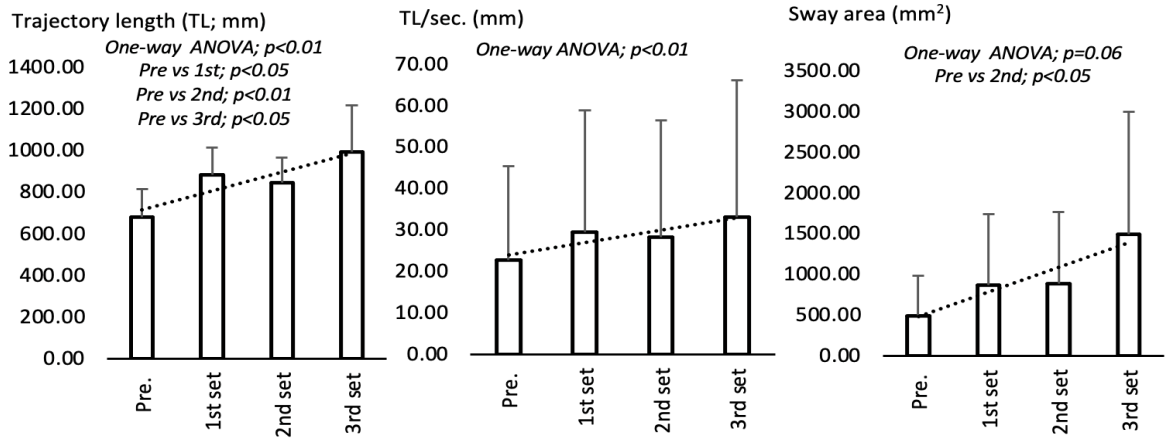

Figure 3. Changes in indices related to the center of gravity, length of trajectory (mm; left fig.), length of trajectory per second (mm; middle fig.), and sway area of the center of gravity (mm^2; right fig.).

Discussion

In this study, it was found that elite handball players experienced a gradual increase in their center of gravity sway after intermittent high-intensity whole-body exercises. Even after only three sets of 30 s of submaximal exercise, the anaerobic power exerted by the players gradually decreased. Moreover, the balance ability also decreased, which is thought to be due to acute fatigue. High-intensity whole-body exercise exacerbates both central and peripheral fatigue. Heavy resistance training loads have also been reported to induce central fatigue (Walker et al., 2012). Furthermore, it has been shown that total body exercises such as high-intensity cycling and repetitive running sprints can cause central fatigue (Goodall et al., 2015). In the present study, subjects showed a clear decrease in power output due to intermittent repetitive maximal anaerobic exercise. In particular, the reduction in PP and PAT was very interesting, and highlighted the ability to produce high power for very short durations (less than 8 s) was not fully restored by a 2-min rest period. The supply and utilization of oxygen by blood circulation during and after exercise may be

important factors in the recovery of muscle output. However, if the recovery time by rest is limited, it can be predicted that repeated intense exercise would gradually decrease the anaerobic energy supply mechanism, resulting in a clear decrease in motor output. Bogdanis et al. (1995) showed that the recovery time of PCr after the Wingate test was more than 6 min to reach 90%. They stated that the factors that inhibit ATP regeneration by the PCr and glycolytic system are the extremely high exercise intensity and the reduced blood flow in the legs during recovery, which is consequently related to the reduced power output during continuous exercise. In contrast, in previous studies on post-exercise balance performance, both anaerobic and aerobic exercise protocols have been reported to have a negative impact on postural control after exercise. In a study of female soccer players (Özkan et al., 2020), it was clearly observed that balance performance was impaired after aerobic and anaerobic exercise fatigue. The protocol for anaerobic loading used by Özkan et al. (2020) included a 30-second WAnT followed by a 4-min rest period, which suggests a higher metabolic fatigue effect. When high-intensity whole-body exercise is followed by intermittent exercise, it is expected that the aerobic energy supply system will be more affected. This is because the recovery of the anaerobic energy supply system may be insufficient. In our study, the subject sprint times were highly correlated with the power exerted in the first WAnT, but there were no correlations with the second and third tests. This result predicts an increase in the percentage contribution of aerobic capacity. It is a well-known finding that lactic acid itself does not directly cause muscle fatigue. However, it has been shown that post-exercise metabolites, lower intramuscular pH, and elevated inorganic phosphorus may have a significant impact on muscle fatigue during high-intensity exercise (Baker et al., 2010). Repetition of intermittent high-intensity exercise, as in the present study, was suggested to cause peripheral and central fatigue and increase acute gravitational instability. Central fatigue is considered to be a neurological type of fatigue that includes loss of concentration, inadequate peripheral to central nervous system transmission, and inadequate mobilization of the motor neurons. Based on our findings, we cannot contribute new details to the fatigue mechanism because we did not conduct neurological and cytological examinations. However, the accumulation of metabolic products due to strenuous exercise can affect nerve transmission and muscle contraction and can be a factor in reducing postural retention capacity. Instability of the center of gravity due to repeated anaerobic exercise can adversely affect the performance of handball players and can also put them at greater risk of injuries. Handball, which requires intermittent high power, requires that daily intermittent high-intensity training be planned, and that physiologically appropriate recovery time be factored in during practices and competitions. Our future work will examine the complex causal relationship between fatigue and body instability during live handball games by investigating the positions, playing time, speed of movement, body contact, and jumps.

Conclusion

After intermittent 30-s maximal effort exercises, the university student handball players' exerted power gradually decreased and their resting center of gravity balance gradually deteriorated. To improve the performance of handball players and prevent injuries, the effects of acute fatigue on body balance must be considered.

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EMPTY NET STRATEGY IN DIFFERENT NUMERICAL RELATIONSHIPS OF HANDBALL: ANALYSIS OF THE MALE BRAZILIAN NATIONAL LEAGUE

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Summary

As handball teams seek for numerical balance or advantage using the Empty Net strategy, this study aimed to analyze the usage of these strategy in different game situations. We analyzed all the matches (n=34) from the 2020 Male Brazilian National League. It found similar results in numerical equality, a higher tendency for turnovers during numerical superiority and a lower tendency for turnovers in numerical inferiority situations.

Keywords: Handball; Empty Net; Game analysis; Numerical relationship

Introduction

In handball, performance analysis researchers have been investigating players' and teams' actions, to seek variables that are related to match results (Ferrari, Sarmento & Vaz, 2019). Studies addressed the team's tactical organization in the highest levels (World Championship and Olympic Games finalists), by analyzing specific situations and using players effectiveness during the game (Daza, Andres & Tarrago, 2017; Gryko, Bodasinski, Bodasinski & Zielinski, 2018; Hansen et al., 2017; Ohnjec, Vuleta, Milanović & Gruić, 2003; Saavedra, Þorgeirsson, Kristjánsdóttir, Chang & Halldórson, 2017).

Actually teams are adopting a strategy that consists in the substitution of the goalkeeper for a court player when the team regains the ball possession, leaving the net empty (Antón, 2010). The increasing usage of the empty net strategy is given due to a game rule modification, which facilitates the exchange of the goalkeeper for a court player (International Handball Federation, 2017). In Brazil, teams are using this strategy to even or reduce the numerical disadvantage during two minutes suspensions or to give numerical advantage (Gilio, 2020).

In this sense, it is important to analyze if the purpose of the strategy utilization is being achieved during the matches. Therefore, some questions emerge when faced with this problem: "How is the Empty Net being used by male Brazilian handball teams?"; "What are the outcomes of the Empty Net in different numerical relationships?". To answer these questions, this study aimed to analyze the usage of the Empty Net strategy and compare the conclusion of the attack with different numerical relationship situations in the Brazilian handball context.

Methods

Notational analysis was adopted as a scientific method, without the observers participating in the game context (O'Donoghue, Holmes & Robinson, 2017; Wright, Carling & Collins, 2014). Due to the video acquisition from searches in public domain sites and the involvement of humans in the research (although they are not identified), this project has been submitted and approved by an Institutional Research Ethics Committee.

To control the opposition's heterogeneous qualities, the sample was based on the highest handball level (Marcelino, Sampaio & Mesquita, 2011; O'Donoghue et al., 2017). We analyzed all the matches (n=34) from the 2020 Male Brazilian National League, totalizing 3931 attack sequences. Matches were observed randomly by the researcher using video playback software and the analyses were made with an electronic *ad hoc* sheet. The protocol used in the analysis was based on performance indicators (Hughes & Bartlett, 2002) presented in Table 1.

Table 1. Description of the variables

Attack Outcome
Goal: one point scored by any team.
Non-Goal: throw out of the goal or in the post, saved by the opponent goalkeeper, or blocked by defense,
Turnover: change of ball possession without a throw to the goal (pass interception, attack foul, steal or attack error).
Numerical Relationship
Equality: if, in the beginning of the offensive process, both teams do not have any two minutes suspensions or have the same number of players suspended.
Superiority: if, in the beginning of the offensive process, the attacking team has one or more players than the opposing team.
Inferiority: if, in the beginning of the offensive process, the attacking team has one or more two minutes suspensions than the opposing team.

To analyze the data reliability and to ensure replication of this study, the analysis consistency was checked for the same researcher (trustworthiness) (O'Donoghue et al., 2017; Thomas, Nelson & Silverman, 2012). The second match observation was initiated 15 days after the first one. An observer with 15 years of experience as a player and eight years of experience as handball coach participated in the *ad hoc* sheet organization.

After the phase described earlier, the observer practiced their observations and data recordings with a practical application, to reach a consensus agreement and decrease the possible errors (Anguera & Mendo, 2013; O'Donoghue et al., 2017). The intraobserver reliability was verified in 12.5% of the sample and the Kappa Cohen statistics were used to measure the agreement index (Fleiss, Levin & Paik, 2003; James, Taylor & Stanley, 2007). The trustworthiness index for intraobserver reached 0.91 for the attack outcome.

RESULTS

The analysis of the data revealed the frequencies of the Empty Net usage for all numerical relationships. Table 2 shows the general and specific frequency of Empty Net usage in each situation.

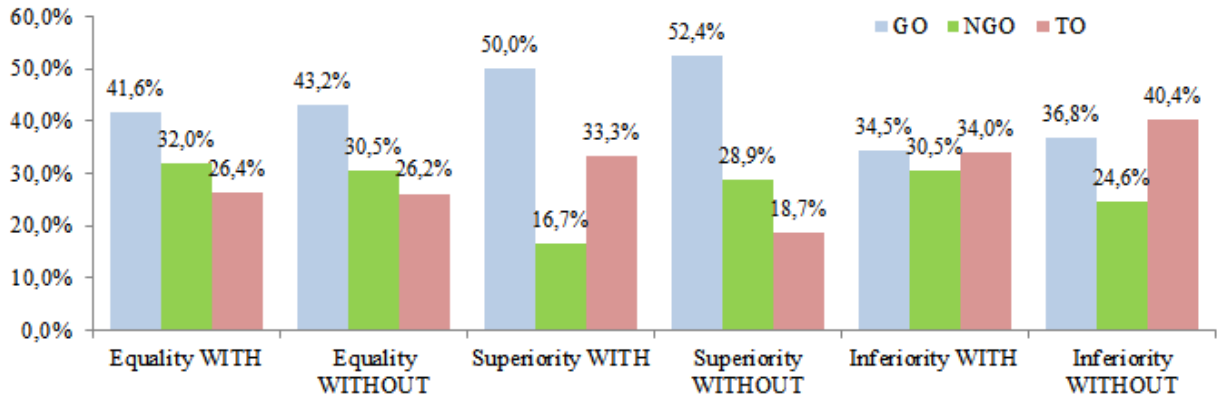
Table 2. Frequency of the Empty Net usage during each numerical relationship.

Numerical situation/condition	General percentage	Intra-class percentage
Numerical Equality (n=3177)		
WITH Empty Net	5.9%	7.3%
WITHOUT Empty Net	75%	92.7%
Numerical Superiority (n=439)		
WITH Empty Net	0.2%	1.4%
WITHOUT Empty Net	11%	98.6%
Numerical Inferiority (n=314)		
WITH Empty Net	5.1%	63.7%
WITHOUT Empty Net	2.8%	36.3%

In a general perspective, it was observed that the matches are played majoritarily without the Empty Net and in numerical equality. But when comparing the usage of Empty Net through the numerical relationships, it was revealed that inferiority was the situation in which teams proportionally most used the strategy.

In addition to the frequencies, the investigation also revealed how the usage of Empty Net influenced the game in each situation. Figure 1 presented the conclusions of attacks in each numerical relationship, with and without Empty Net.

Figure 1. Results of attacks in each numerical relationship, with and without the Empty Net strategy (GO: goal; NGO: non-goal; TO: turnover).



The analyzed context revealed that numerical equality presented a tendency to attacks that conclude with a throw and a goal (GO), independently of the Empty Net. The attacks which started in numerical superiority were concluded with a goal in both observed situations. The use of the Empty Net in a superiority situation increases the frequency of Turnovers and decreases the occurrence of throws than without Empty Net. When the teams started in numerical inferiority the goal occurrences were smaller than the others numerical relationships. Furthermore, the usage of Empty Net in inferiority demonstrates a smaller frequency of Turnover than when not using.

Discussion

The aim of this study was to analyze the usage of the Empty Net strategy by male Brazilian handball teams in different situations. It was observed that the Empty Net was used more often in numerical inferiority situations. The results of the attacks showed a similarity in numerical equality, but some particularities during numerical asymmetry.

While observing the frequency of the Empty Net usage, it could be noted that the numerical relationship can influence the decision to use these strategy. These affirmation can als be confirmed by interviews with expert handball coaches from Brazil, which showed that the usage of the Empty Net is given by the need of equalizing or reducing the numerical relationship in the attack phase while having one or more suspensions (Gilio, 2020). Therefore, its use can be attributed to different situations in the game, and it can be linked to the score and the time of the match, which depends on the understanding (and training) of this strategy by coaches and players.

In numerical equality the usage of the Empty Net generates a numerical advantage in attack (Antón, 2010), which was confirmed in 7.3% of the attacks. Despite that, as the throws to goal direction and its conversion are important performance indicators (Almeida, Merlin, Pinto, Torres & Cunha, 2020; Vinha et al., 2020; Daza et al., 2017), the pretended advantage could not be observed in this study due to the similarity in attacks' results during numerical equality with and without Empty Net (Figure 1).

During the numerical superiority situations it could be observed a lower usage of the Empty Net, but a higher tendency to occur a turnover when it was used. As well as to numerical equality, the usage of Empty Net may not correspond to the attempt of obtaining advantage, since the throws to goal are important to game result (Saavedra et al., 2017). Furthermore, it must be observed that when a turnover occurs while using the Empty Net, the opponents may have spatial and numerical advantage in their fastbreak due to the absence of the goalkeeper. Specifically in these game

situations, the use of Empty Net brought a greater risk of turnovers for the team that is already in numerical advantage, which may be related to the offensive organization and/or the actions of the defenders. Furthermore, in these situations, although the team is at an increased numerical advantage through the use of Empty Net, the pressure for a positive outcome of the attack can increase the pressure on the attackers, and lead to more errors.

The numerical inferiority attacks with Empty Net have shown a higher tendency to be concluded with a throw in goal and a lower tendency to turnover ball possession when compared to situations without the strategy. It can be confirmed again by the importance of the throws to game results (Saavedra et al., 2017) and demonstrate that coaches are achieving their objective of maintaining the ball possession during the attacks with one or more suspensions (Gilio, 2020).

Conclusion

With the intention to contribute to the knowledge about the Empty Net strategy, this study collaborates with coaches' choice of adopting this strategy in their game models, besides presenting the best situations for its utilization. It was found that Empty Net usage may not be advantageous in numerical equality and superiority and, in numerical inferiority, the usage of the Empty Net may contribute to achieve the game objectives and coaches' intentions.

Finally, it can be suggested efforts to analyze other situations involving the Empty Net usage, specially comparing the numerical relationship in the attack half court (e.g. numerical equality without Empty Net x numerical inferiority with Empty Net), analysing the relationships established by the players before losing the ball or throw. In addition to these research findings, other contexts to be analyzed are the match status, the match period and the next ball possession of the opponents when teams use the Empty Net._

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DEFENCE TACTICS IN BEACH HANDBALL

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Summary

In Beach Handball, the numerical superiority of the attacking team poses the question of how the optimal defence tactics might look like. Our analysis of 40 Beach Handball world championship games (20 female) revealed that for males attempting to block an opponent's shot and for females provoking throws near the side-lines or bounces are the most efficient tactical defence behaviours to prevent the opponent from promising scoring opportunities.

Keywords
defence strategy, blocking, scoring position, team sports, coaching

Introduction

Beach Handball has evolved over the last few decades from a recreational sport to a highly popular sport at the Youth Olympic Games (see Bebetsos, 2012; Mancha-Triguero et al., 2020; Zapardiel, 2018, 2020). Unsurprisingly, this development leads to tactical as well as technical adaptions, which might promise a higher probability of success. Nevertheless, there are currently only a few scientific studies investigating tactical or technical performance parameters in beach handball (Bon & Pori, 2020).

One of the core aspects of beach handball is the numeric superiority of the attacking team (4 attacking players vs 3 defending players and 1 goalkeeper). This numeric superiority is achieved through an additional field player (specialist), who replaces the goalkeeper during the attack phase. This substitution of the goalkeeper is provoked by the framework of rules: goals scored by Specialists/Goalkeeper are automatically awarded with two points, whereas goals scored by other players are usually awarded with one point unless they perform a special shot (spin-shot, inflight), which is, as well, rewarded with two points.

Due to this numeric superiority of the attacking team, the tactical behaviour of the defending team is of particular importance, as the defending team might not be able to prevent the attacking team´s attempts to score in general and, thus, rather aims to lower the probability of successful scoring attempts. Nevertheless, Zarpadiel (2018) argued that the defending style can guide the playing style of the attacking team. For this reason, it seems advisable to apply specific tactical aspects to lower the scoring probability of the attacking team

One tactical aspect might be to provoke scoring attempts from specific shooting positions. Skandalis and colleagues (2017) showed that the most efficient shooting position in female Beach Handball appears to be the centre position with a scoring probability of 60.2%. The authors assume

that, these results derive from the ‘specialist’, as the only player being able to score two points with a normal shot, positioned in the centre. Consequently, the defending team might focus on defending scoring attempts from the centre position. However, it is important to mention, Moreover, Skandalis and colleagues (2017) did not distribute between different shooting types, which is of particular interest in Beach Handball as goals are rewarded with different points based on the respective shooting type.

The different shooting types should also be considered as a second tactical aspect that the defence team might consider to lower the scoring probability of the attacking team. Zarpadiel (2018) showed that the finalist of the 2017 European Women's Championships had a higher throwing efficiency for spin shots and specialist throws compared to other teams. In contrast, no differences were found for the goalkeeping performance. One might assume that the technical-tactical defence behaviour, especially against spin shots and specialist shots, has a great influence on the probability of success of the defence. In line with this assumption, Gkagkanas (2018) argued that further research investigating technical-tactical issues in beach handball is needed. The resulting knowledge might provide a useful tool for coaches in order to adapt the tactical defence behaviour of their teams.

Therefore, the purpose of this study was to investigate individual and group tactical aspects of the defending team, which might be associated with a higher defence success rate. In detail, this study investigated the scoring probability (%) for different field areas and the influence of tactical defence behaviour like (1) blocking a scoring attempt, (2) forcing the offence team to play long-distance assists, and (3) provoking the offence team to bounce the ball on the scoring probability.

Materials and Methods

A total of 40 (20 male, 20 female) videotaped games from the Beach Handball World Cup in Kazan (Russia) in 2018 were used for our post-hoc observation study. To analyse the individual and group tactics of the defending team, only attacks against an organized defence in 4 vs. 3 were considered, leading to a total of 2,477 defence situations. More in detail, we investigated 1,141 defence situations, including 908 scoring attempts, from the female games and 1,336 defence situations, including 1,159 scoring attempts, from the male games. These game-specific situations were analysed by three Beach Handball experts (national coach level/ international player level) with regard to the variables: position of the player attempting to score (15 areas defined by 5 zones within the goal area, 5 zones at the 6m line and 5 zones before the goal area; Figure 2), the number of passes played before the scoring attempt, number of defence players aiming to block the scoring attempt, total number of bounces made by the attacking team, type of player attempting to score (field player/specialist), distance of the assist played before the attempt to score, technical mistakes, throwing type (one-point shot, in-flight shot, spin shot), outcome of the scoring attempt (1 point/ 2 points/ no points/ penalty). The data was analysed via chi-squared tests, and risk ratios (RR) with 95% confidence intervals reported as standardized measures of effect size, as well as via a logistic regression.

Results

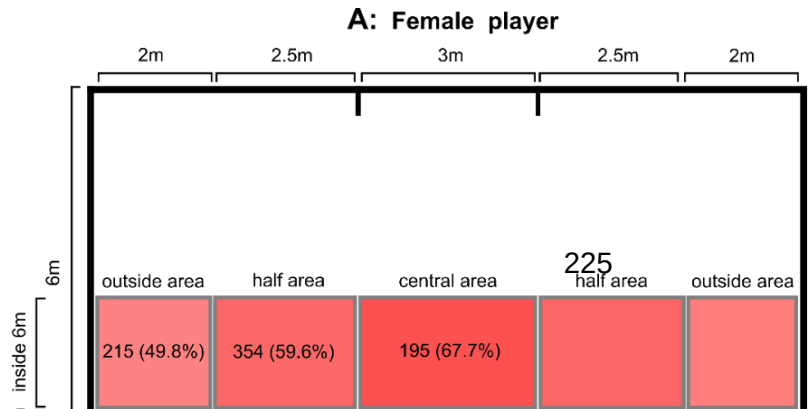
A descriptive overview of the throwing types used and their success rates for scoring is shown in Table 1.

Table 1. Descriptive illustration of throwing types and their scoring success rates for (A) females and (B) males respectively.

		female		male	
Shot-type	Player	Number of attempts	Success rate	Number of attempts	Success rate
One-point shot	field player	60	60%	28	61%
	specialist	212	59%	249	55%
Spin-shot	field player	445	54%	540	59%
In-flight shot	field player	191	57%	342	60%

The positional distribution in which the players attempted to score and the respective probabilities of success can be seen in Figure 2.

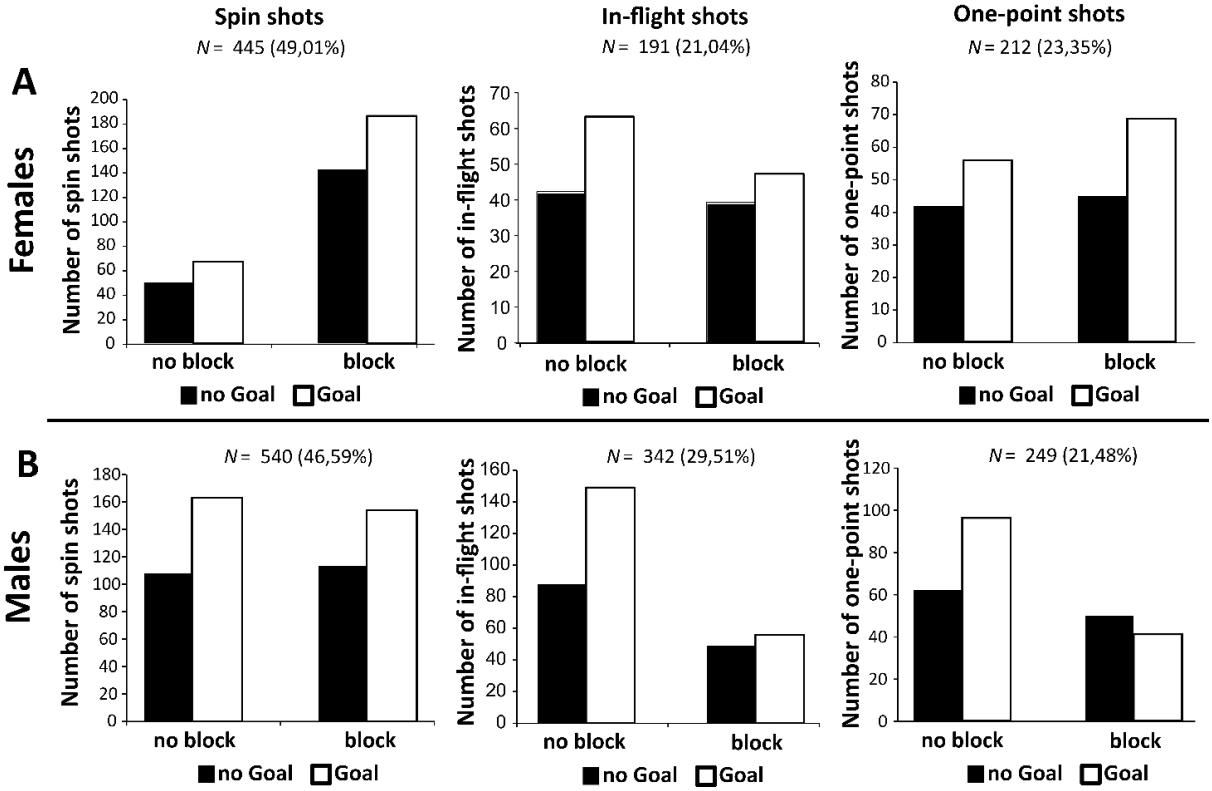
Figure 2. Scoring probability (%) for each area of the field, for (A) female and (B) male teams respectively. The probabilities for both outside and both half areas were combined.



Chi-square tests revealed that the likelihood to score a goal increases significantly as closer to the centre the scoring attempt is performed for females ($\chi 2$[2] = 13.50, p = .001, RR[outside/half/centre] = 1.08, 95% CI = [.94, 1.23]) but not males ($\chi 2$[2] = 0.38, p = .827, RR[outside/half/centre] = 1.03, 95% CI = [.91, 1.16]). A further analysis of the different throwing types performed by female players demonstrates that this effects applies only for in-flight shots ($\chi 2$[2] = 11.49, p = .003, RR[outside/half/centre] = 1.24, 95% CI = [.85, 1.81]) and spin shots ($\chi 2$[2] = 10.90, p = .004, RR[outside/half/centre] = 1.09, 95% CI = [.96, 1.24]) but not one-point shots ($\chi 2$[2] = 0.73, p = .693, RR[outside/half/centre] = .86, 95% CI = [.58, 1.26]).

When looking at the tactical defensive behaviour of attempting to block the attacker's shot chi-square tests revealed that for male teams a blocking attempt significantly lowers the attacker's probability to score a goal ($\chi 2$[1] = 6.68, p = .010, RR[no block/ one or two blocks] = 0.88, 95% CI = [.79, .97]). These findings were not replicated for female teams ($\chi 2$[1] = 2.56, p = 1, RR[no block/ one or two blocks] = 1.01, 95% CI = [.95, 1.06]). Figure 3 and additional chi-square tests showed that the significant effect in male teams derives from block attempts against one-point shots ($\chi 2$[1] = 5.14, p = .023, RR[no block/ one or two blocks] = .79, 95% CI = [.65, .96]) and that a similar trend can be seen for in-flight shots ($\chi 2$[1] = 2.37, p = .124, RR[no block/ one or two blocks] = .88, 95% CI = [.76, 1.03]), but not spin shots ($\chi 2$[1] = .25, p = .621, RR[no block/ one or two blocks] = .95, 95% CI = [.80, 1.13]).

Figure 3. Descriptive illustration of a block attempt on each shot-type for (A) females and (B) males respectively.



A binominal regression was run to understand the effect of the number of passes before the scoring attempt, the number of bounces before the scoring attempt, the distance of the assist before the scoring attempt and passive play on the attacking teams' probability to score a goal. Only in female teams the number of bounces before the scoring attempt significantly predicted the scoring probability of the attacking team (table 2).

Table 2. Results of the logistic regression

	Estimate	Std. Error	Wald *z*	*p*	Odds ratio
Female					
Number of passes before the scoring attempt	-.010	.018	-.559	.576	0.990
Numer of bounces before the scoring attempt	-.435	.168	-2.583	.010**	0.647
Distance of the assist before the scoring attempt	-.046	.026	-1.772	.076	.954
Passive play	-.577	.317	-1.824	.068	.561
Male					
Number of passes before the scoring attempt	-.020	.017	-1.230	.219	.980
Numer of bounces before the scoring attempt	.146	.191	.764	.445	1.157
Distance of the assist before the scoring attempt	-.010	.022	-.467	.640	1.010
Passive play	-.110	.421	-.260	.795	.896

Note * < .05, **< .01

Discussion

To optimize the tactical behaviour of a defending team in beach handball one might argue that some areas on the field should be particularly well defended, as these are preferred by the attacking team due to their higher scoring probability. In line with Skandalis (2017) we found that the most efficient shooting position for female beach handball teams appear to be the centre position with a scoring probability of 63.4%. Although Skandalis (2017) did not differentiate between different areas and their distances from the goal, he assumed that these results derive from the frequent use of the 'specialist', as the only player allowed to score two points with a normal shot, at the centre position. This assumption could not be confirmed by our findings. It seems rather that for females the greater the throwing distance and/or the smaller the throwing angle, the lower is the scoring probability. Therefore, it seems reasonable to assume that the high probability to score from the centre position is not due to the specialist position, but to the line player who usually attempts to score at a centre position, close to the goal, with a wide throwing angle and little pressure. This assumption might only partly apply for male teams. While the findings for the male teams also demonstrate a lower scoring probability from a greater distance, no significant difference was found between the different positions. Greater jumping capacity and athletics of males could be a reason for the higher scoring probability from outside areas, as male players have more time to perform a spin- or in-flight shot. The gender differences in jumping power and athletics (Åstrand et al., 2013) might also explain the effect of blocking attempts by male players on the attacker's scoring probability, whereas no effect was found for blocking attempts by female players. However, female teams seem to benefit from another tactical defensive behaviour to reduce the opponent's scoring probability, namely provoking bounces by the attacking team before the scoring attempt. An increased number of bounces by the attacking team might disrupt the flow of the attack or build up pressure which in turn might lead to bad decisions.

Conclusion

Whereas the attempt to block an opponent's shot seems to be a promising direct tactical defence behaviour to lower the opponent´s probability to score for male teams, female teams might be more successful with indirect tactical defence behaviours as provoking bounces or throws near the side-lines by the attacking team. Coaches should be aware of these gender differences in the efficacy of different tactical defence behaviours and probably adjust the training if necessary. Nevertheless, we should keep in mind that the handball discipline beach handball seems to be just at the beginning of its technical-tactical evolution, so that, we expect rapid developments and adaptions in particular on the tactical level. In line with this assumption we aim to motivate the (scientific) beach handball community for further investigations of beach handball specific tactical behaviour.

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RELATIONSHIP BETWEEN MORPHOLOGICAL AND MOTOR VARIABLES WITH EVALUATION OF COMPETITIVE PERFORMANCE IN SLOVENIAN YOUTH MALE HANDBALL PLAYERS

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Summary

The purpose of this study was to determine the correlation between the assessment of the competitive performance in Slovenian youth male national team handball players who participated at the European Youth Championships in August 2021 in Croatia and the results obtained in the set of motor and morphological variables. Several significant correlations were identified. Of particular interest are the correlations between the assessment of playing performance and the parameters of speed and jump power.

Key Words: young handball players, creeping, static strength.

Introduction

In the calendar year 2020, virtually all handball competitions were stopped due to the Covid-19 epidemic. Only competitions at the highest levels of national and international club competitions took place. In the younger age categories, in many countries there was also a very limited possibilities to train handball. In 2021, international competitions of the youth national team at European level have been restored. The Slovenian men's national team has always been very successful in this category, and they have taken places in the top. Also, at the European Cadet Championships in August 2021, which was in Croatia, the Slovenian national team played very well and took fourth place. We assumed that the time of reduced training was likely to cause a decline in motor skills and affect changes in body composition. In order to find out how the appropriate physical preparedness had an impact on the performance of the individual players in this competition, we carried out a short survey. Based on the expert opinion of six experts who monitored the national team matches and various measurements of motor abilities and morphology, we tried to find links between the results in the tests of different fitness and morphological measurements and the individual's performance.

Methods

Sample

The subjects were 16 handball players members of slovenian youth handball team who paticipated on MEN'S 19 EHF EURO in August 2021. At the time of measurement, the study subjects were 18.0±0.6 years old on average. Their average body height was 185.8±5.7 cm and body mass 85.9±8.2 kg.

Variables

The sample of variables included 13 motor variables, 8 selected anthropometric variables and an assessment of the playing quality of the measured players. To assess the anthropometric characteristics, we used a standard anthropometric battery of 24 dimensions, from which we calculated the percentage of muscle and bone mass and the values of the subcutaneous fat and somatotype of the players (Duquet and Hebbelinck, 1977). The assessment of the explosive and elastic power of the legs was made using the tensiometric platform; the study subjects performed four different jumps: a squat jump (SJ) and a counter movement jump (CMJ), 25-cm drop jump and 45-cm drop jump. The ability to generate sprint speed was assessed using sprint times over 5 m, 10 m and 20 m with a standing start (T5m, T10m, T20m and Vmax). Repeated sprint ability was assessed with an 8X40-m maximal shuttle run test (40-m MST) (Baker, Ramsbottom, & Hazeldine, 1993). It's a multiple sprint tests incorporating changes of direction. Subjects completed one trial of the 40-m MST (8 × 40-m; 20 s rest periods). We took into consideration a sum of time obtained in all eight repetitions and index calculated from the ratio of the worst and best time achieved to each recurrence. To assess the speed of the ball in a handball shot, the subjects performed two shots - a shot from the ground and a shot in the jump. The speed of the shots was measured using a properly calibrated radar (Emg companies, inc., USA, model 52000), which was placed 1 m behind the handball goal. Running endurance was assessed using the 30-15IFT test (Buchheit, 2005a; Buchheit, 2005b). This is an intermittent fitness test (with interruptions) performed on a handball court – 30 s of running and 15 s of rest. The subjects were running at a pace dictated by a sound signal. The running speed increased with each repetition and the runners persevered until exhaustion or so long as they could run the specific distance foreseen in the interval. The obtained result enables the approximate maximum use of oxygen to be calculated using the following formula: VO2max(ml/min/kg) = 28.3 – 2.15 * G – 0.741 * A – 0.0357 * P + 0.0586 * A * V + 1.03 * V, where: G is gender (1 = male, 2 = female), A is age, P is weight and V is the final velocity recorded in the test. All measurements were conducted by the same people, using the same measurement technology. The evaluation of playing performance was determined with the help of six evaluators, who ranked players in terms of their contribution to the quality of the game.

Table 1

Sample of motoric variables

Test	Measured capacity	Measuring unit
5-m sprint – standing start	Sprint speed	Seconds
10-m sprint – standing start	Sprint speed	Seconds
20-m sprint – standing start	Sprint speed	Seconds
Vmax	Sprint speed	$m \cdot s^{-1}$
Ground shoot	Speed of the ball at shot	$m \cdot s^{-1}$
Jump shoot	Speed of the ball at shot	$m \cdot s^{-1}$
8X40m MST mean	Anaerobic capacity	Seconds
8X40m MST index	Anaerobic capacity	index
VO_2max	Maximal O_2 consumption	ml/min/kg

Squat Jump	Explosive power of leg	Cm
Counter Movement Jump	Elastic power of leg	Cm
Drop jump 25cm	Elastic power of leg	Cm
Drop jump 45 cm	Elastic power of leg	Cm

Table 2
Sample of morphological variables

Variable	Measured dimension	Measuring unit
Body height	Longitudinal dimension	cm
Body mass	Body voluminousness	kg
% Subcutaneous fat	Quantity of subcutaneous fat	%
% Muscle mass	Quantity of muscle mass	%
% Bone mass	Quantity of bone mass	%
Ectomorphy	Ectomorphic component of somatotype	Coefficient
Mesomorphy	Mesomorphic component of somatotype	Coefficient
Endomorphy	Endomorphic component of somatotype	Coefficient

Tables 1 and 2 present a sample of motor and morphological variables, measured dimensions and unit of measurement used.

Data analysis
The data were analysed using the statistical package SPSS 20.0. Basic parameters of the distribution of variables were calculated (mean, standard deviation, minimum and maximum values, kurtosis, skewness, and Kolmogorov-Smirnov test of normality). The players were ranked according to the average of the ranks of the six evaluators. Spearman Correlation Coefficient) was used to test the degree of correlation among the variables. A probability level of 0.05 or less was taken to indicate significance. The results, however, were logically altered – in sprints, the lower values were considered as better result; we took into account as well that the lower rank value mean better rank.

Results

Tables 3 and 4 presents the basic statistical characteristics of morphological and motor variables. In tables average values, standard deviations, minimum and maximum values, kurtosis, skewness, and significance of the Kolmogorov-Smirnov test are presented.

Table 3
Basic statistical characteristics of morphological parameters

Parameter	$\bar{x}$	S	min	max	kurt	skew	pK-S

Age	18,00	4,52	17	19	0,000	-0,217	0,000
Body height	185,78	5,72	173,5	193,9	-0,476	-,0548	0,200
Body mass	85,85	8,21	69,4	103,6	0,300	-,020	0,200
% Subcutaneous fat	10,90	3,69	5,3	17,3	0,432	-0,863	0,191
% Muscle mass	53,66	2,57	46,1	57,4	-0,992	1,697	0,200
% Bone mass	16,43	1,42	14,2	20,2	0,553	0,573	0,200
Ectomorphy	2,45	0,97	0,1	4,4	-0,107	0,217	0,200
Mesomorphy	5,10	1,06	2,6	7,2	-0,125	0,378	0,200
Endomorphy	2,49	0,89	1,0	4,5	0,621	0,248	0,135

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.

Table 4

Basic statistical characteristics of motoric parameters

Parameter	$\bar{x}$	S	min	max	kurt	skew	pK-S
T_{5m}	1,02	0,34	0,97	1,09	0,743	-0,642	0,,200
T_{10m}	1,74	0,05	1,66	1,84	,0175	-0,793	0,200
T_{20m}	2,97	0,08	2,82	3,13	0,180	-0,760	0,200
Vmax	8,76	0,31	8,15	9,34	0,102	-0,522	0,200
GS	103,04	5,90	91	117	0,435	0,225	0,063
JS	95,62	5,77	85	109	0,196	-0,143	0,200
8X40-m MST_sum	65,21	2,17	62,27	70,15	0,696	-0,135	0,188
8X40-m MST_index	4,81	2,19	1,61	10,54	0,977	1,122	0,038
VO_{2max}	50,30	3,32	38,41	55,25	-1,890	5,845	0,012
SJ	37,47	4,33	25,83	45,93	-0,523	1,142	0,044
CMJ	40,93	4,36	30,78	47,90	-0,643	-0,046	0,200
DJ 25cm	34,29	4,25	26,74	44,74	0,202	0,100	0,200
DJ 45 cm	35,79	5,43	26,51	49,60	0,165	0,513	0,200

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; T_{5m} - 5-m sprint – standing start; T_{10m} - 10-m sprint – standing start; T_{20m} - 20-m sprint – standing start; Vmax – maximal sprint velocity; GS – ground shoot speed; JS – jump shoot speed; 8X40-m MST_sum – sum of 8 40 sprints; 8X40-m MST_index – anaerobic capacity index;; VO_{2max} - Maximal O_2 consumption; SJ - Squat Jump; CMJ - Counter Movement Jump; DJ25cm – drop jump 25 cm; DJ45cm – drop jump 45 cm.

The data reveal that all measured parameters, with exception of VO_{2max}, 8X40-m MST_index and squat jump, are normally distributed.

Tables 5 and 6 show the results of Spearman Correlation coefficients based on which we established whether there were any statistically significant relationships between the morphological and motor variables and the individual's performance of the players.

Table 5

Values of Spearman Correlation coefficients between playing performance assessment and morphologic variables

	Performance quality assessment	
	Spearman corr. Coeff.	Sig. of Spearman corr. Coefficient
Body height	0,111	0,589
Body mass	0,055	0,788
% Subcutaneous fat	0,378	0,057
% Muscle mass	0,682	0,050*
% Bone mass	-0,145	0,481
Ectomorphy	0,011	0,956
Mesomorphy	-0,160	0,436
Endomorphy	0,332	0,098

Table 5 shows that among the morphological characteristics, only % of muscle mass indicates a significant positive relationship. The power of the coefficient is moderate. This points to the fact that the players with higher percent of muscle tissue have higher probability to be successful in handball. In any case, this fact is entirely in line with previous research, in which researchers report that amount of muscle mass play an important role in handball players successfulness (Šibila, & Pori, 2009; Mohamed, et al., 2009; Chaouachi, et sl., 2009). From the point of view of the selection of players in handball, the interesting fact is that, given the playing performance, high players do not dominate. In any case, coaches in the national team also include players with a high height value, but in terms of playing performance at this age they are even less dominant.

Table 6

Values of Spearman Correlation coefficients between playing performance assessment and motoric variables

	Performance quality assessment	
	Spearman corr. Coeff.	Sig. of Spearman corr. Coefficient
T_{5m}	0,409	0,038*
T_{10m}	0,444	0,023*
T_{20m}	0,490	0,011*

Vmax	0,415	0,035*
GS	0,007	0,973
JS	0,105	0,610
8X40-sum	0,487	0,012*
8X40-m_index	0,182	0,373
Vo_{2max}	0,345	0,085
SJ	0,181	0,375
CMJ	0,413	0,036*
DJ-25cm	0,205	0,315
DJ-45cm	0,001	0,995

Legend: T_{5m} - 5-m sprint – standing start; T_{10m} - 10-m sprint – standing start; T_{20m} - 20-m sprint – standing start; Vmax – maximal sprint velocity; GS – ground shoot speed; JS – jump shoot speed; 8X40-m MST_sum – sum of 8 40 sprints; 8X40-m MST_index – anaerobic capacity index;; VO_{2max} - Maximal O_2 consumption; SJ - Squat Jump; CMJ - Counter Movement Jump; DJ25cm – drop jump 25 cm; DJ45cm – drop jump 45 cm.

Among the motor variables, sprint parameters are significantly related to rank. The strength of the correlations is moderate to strong. The same is valid for the significant relation of ranks and sum of results obtained in the 8X40m MST test and ranks and CMJ.

Discussion and Conclusions

We may conclude from our study that the amount of muscle mass, sprint parameters, jump power indicator CMJ and result in RSA test were in a significant positive relationship with assesment of playing perfomance by subjects included in our survey. It is obvious that the more successful players maintained their advantages in the field of motor skills even at a time when the training of handball players was limited due to the epidemic. This enable them to play quality handball and achieve high competitive efficiency. For this age category, the results are somewhat expected and are also in line with the general theory of performance in handball regarding the dominance of players with a certain morphological and motor structure. It is interesting to note that players with a very pronounced body height do not dominate the Slovenian national team in this age category. They are somehow overshadowed by explosive and fast players with good technical and tactical knowledge. A typical example of such a player is certainly the MVP of the championship Mitja Janc. His body height reaches only average values, but he is an extremely explosive, fast and skilful player. However, it is definitely necessary to be careful about this, as the advantages of very tall players can be better expressed in older categories.

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COMPARATIVE ANALYSIS OF THE USE AND EFFECTIVENESS OF EMPTY GOAL TACTICAL RESOURCE IN 7 VS 6 ATTACK SITUATIONS IN 2018 AND 2020 EUROPEAN WOMEN'S HANDBALL CHAMPIONSHIPS

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Summary

The objective was to analize the use of empty goal tactical resource in 7 vs 6 attack situations, and its influence on the score in 2018 and 2020 European Women's Handball Championships. All the championships' games were digitally recorded using the official championship tv signal, and analized using an ad hoc designed tool. Results showed that in 2020 its use considerably increased and had more positive than neutral or negative influence on the partial score result.

Keywords: Handball, European Championship, sport performance, empty goal, 7 vs. 6.

Introduction

This research studies the use of the empty goal tactical resource in 7 vs 6 attack situations and its influence on the partial score in the 2018 and 2020 European Women's Handball Championships, just after the modifications of the rules of the game related to the substitution of the goalkeeper for an additional player entering into force on July 1, 2016. This change in the rules made possible the substitution of the goalkeeper by an additional player, leaving the goal empty without being necessary for the additional player to enter the court with a shirt of the goalkeeper's colour and different from the rest of court players. Due to the fact of this change in the rules, this study aims to analyze the use, effectiveness and evolution of the empty goal tactical resource focused on 7 vs 6 attack situations in the last two European Women's Handball Championships, since then, and according to most authors, the options and the dynamics of the game have changed significantly.

Methods

It is an observational-notational study in which 93 of the 94 matches played in 2018 and 2020 European Women's Handball Championships were viewed (one video file was damaged) and the variables of the study were identified, registered and analyzed. The descriptive analysis of the data was carried out with the statistical program SPSS v.26, using frequency distributions and crossed tables with observed and expected frequencies. A total of 80 7 vs 6 attack situations were identified in the 2018 European Championship, and 145 in 2020 European Championship, making a total of 225 observation units analyzed. For this, an ad hoc instrument was built in excel sheets where the

data of all the games viewed were organized by championship and according to groups, competition phases and teams were collected, placing the variables to be analyzed in the columns, and in the rows the 225 units of observation identified.

Results

Figure 1 shows the total number of times each team used the empty goal tactical resource in 7 vs 6 in each championship.

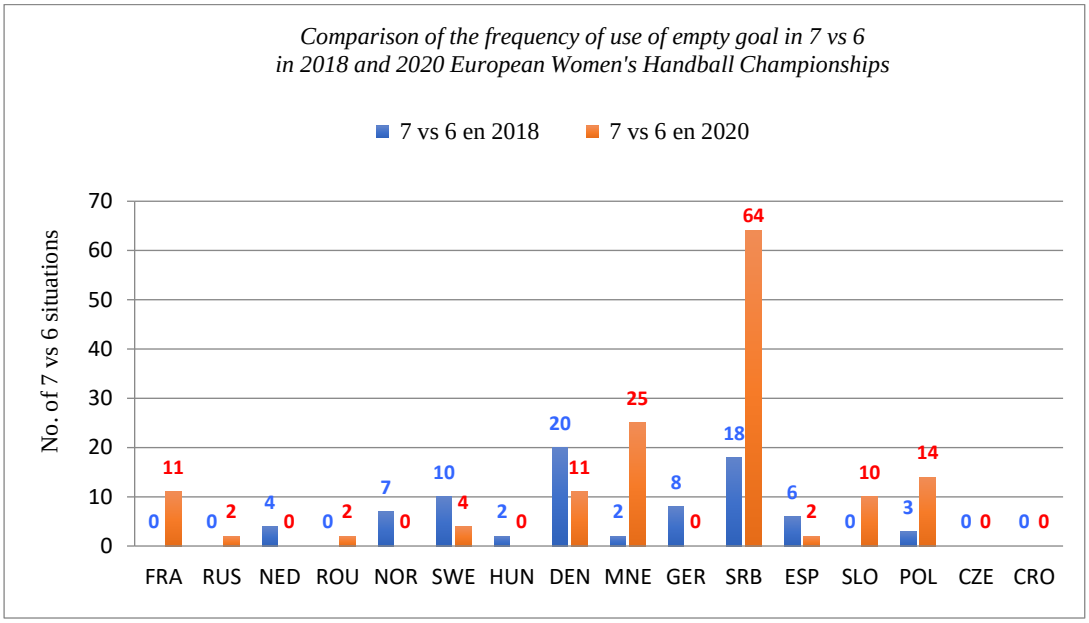

Figure 1. Comparison of the total frequency of use of empty goal tactical resource in 7 vs. 6 by each team in each championship.

Table 1 shows the data from the descriptive analysis carried out. In it, the 16 participating teams are presented (they were the same in both championships) ordered according to the classification obtained in the 2018 championship, and the number of situations of use of the empty goal in 7 vs 6, grouped in Group phase, Main round + Final phase, and Total, by each of the teams and championship.

In Table 2, it is possible to observe and analyze the influence on the partial score of each situation of use of the empty goal in 7 vs. 6 by team and phase of the 2018 championship. It presents the number of situations of use of the empty goal in 7 vs. 6 grouped according to the result in the partial score of each of these situations. Thus, they are shown grouped in: positive, negative or neutral result, and the final balance.

In Table 3, as in Table 2, it is possible to observe and analyze the influence on the partial score of each situation of the use of empty goal in 7 vs. 6 attack situations by team and phase of the 2020

championship. This Table 3 also shows the number of 7 vs. 6 attack situations grouped in positive, negative or neutral result, and the final balance.

Table 1. Comparison of the frequency of use of the empty goal in 7 vs 6 attack situations by team and championship phase in the 2018 and 2020 European Women's Handball Championships.

Teams	Final classification achieved in the championship		Phase of championship	Empty goal situations 7 vs 6	
	2018	2020		2018	2020
				n	*n*
FRA	1º	2º	Group phase	0	2
			Main round + Final phase	0	9
			Total	0	11
RUS	2º	5º	Group phase	0	0
			Main round + Final phase	0	2
			Total	0	2
NED	3º	6º	Group phase	2	0
			Main round + Final phase	2	0
			Total	4	0
ROU	4º	12º	Group phase	0	0
			Main round + Final phase	0	2
			Total	0	2
NOR	5º	1º	Group phase	7	0
			Main round + Final phase	0	0
			Total	7	0
SWE	6º	11º	Group phase	0	1
			Main round + Final phase	10	3
			Total	10	4
HUN	7º	10º	Group phase	2	0
			Main round + Final phase	0	0
			Total	2	0
DEN	8º	4º	Group phase	9	9
			Main round + Final phase	11	2
			Total	20	11
MNE	9º	8º	Group phase	2	18
			Main round + Final phase	0	7
			Total	2	25
GER	10º	7º	Group phase	8	0
			Main round + Final phase	0	0
			Total	8	0

SRB	11º	13º	Group phase	6	64
			Main round + Final phase	12	-
			Total	18	64
ESP	12º	9º	Group phase	5	2
			Main round + Final phase	1	0
			Total	6	2
SLO	13º	16º	Group phase	0	10
			Main round + Final phase	-	-
			Total	0	10
POL	14º	14º	Group phase	3	14
			Main round + Final phase	-	-
			Total	3	14
CZE	15º	15º	Group phase	0	0
			Main round + Final phase	-	-
			Total	0	0
CRO	16º	3º	Group phase	0	0
			Main round + Final phase	-	0
			Total	0	0
Championship total				80	145
Mean per team				5,00	9,06
Minimum per team				0	0
Maximum per team				20	64

Table 2. Influence on the partial score of each empty goal situation in 7 vs. 6 by teams and phase of the 2018 championship.

Teams	Phase of championship	Influence on the partial score of each empty goal situation in 7 vs 6							
		Positive result		Neutral result		Negative result		Total	Final balance
		n	% of the total	*n*	% of the total	*n*	% of the total	*n*	
FRA 1º	Group phase	0	0%	0	0%	0	0%	0	Not used
	Main round + Final phase	0	0%	0	0%	0	0%	0	Not used
	Total	0	0%	0	0%	0	0%	0	Not used
RUS 2º	Group phase	0	0%	0	0%	0	0%	0	Not used
	Main round + Final phase	0	0%	0	0%	0	0%	0	Not used
	Total	0	0%	0	0%	0	0%	0	Not used
NED 3º	Group phase	2	100%	0	0%	0	0%	2	Positive
	Main round + Final phase	0	0%	1	50%	1	50%	2	Negative
	Total	2	50%	1	25%	1	25%	4	Neutral
ROU 4º	Group phase	0	0%	0	0%	0	0%	0	Not used
	Main round + Final phase	0	0%	0	0%	0	0%	0	Not used
	Total	0	0%	0	0%	0	0%	0	Not used
NOR 5º	Group phase	2	29%	4	57%	1	14%	7	Positive
	Main round + Final phase	0	0%	0	0%	0	0%	0	Not used
	Total	2	29%	4	57%	1	14%	7	Positive
SWE 6º	Group phase	0	0%	0	0%	0	0%	0	Not used
	Main round + Final phase	3	30%	7	70%	0	0%	10	Positive
	Total	3	30%	7	70%	0	0%	10	Positive
HUN 7º	Group phase	0	0%	2	100%	0	0%	2	Neutral
	Main round + Final phase	0	0%	0	0%	0	0%	0	Not used
	Total	0	0%	2	100%	0	0%	2	Neutral

DEN 8º	Group phase	5	56%	4	44%	0	0%	9	Positive
	Main round + Final phase	2	18%	7	64%	2	18%	11	Neutral
	Total	7	35%	11	55%	2	10%	20	Neutral
MNE 9º	Group phase	1	50%	1	50%	0	0%	2	Positive
	Main round + Final phase	0	0%	0	0%	0	0%	0	Not used
	Total	1	50%	1	50%	0	0%	2	Positive
GER 10º	Group phase	6	75%	1	12,5%	1	12,5%	8	Positive
	Main round + Final phase	0	0%	0	0%	0	0%	0	Not used
	Total	6	75%	1	12,5%	1	12,5%	8	Positive
SRB 11º	Group phase	3	50%	2	33%	1	17%	6	Positive
	Main round + Final phase	4	33%	7	58%	1	8%	12	Neutral
	Total	7	38,89%	9	50%	2	11,11%	18	Neutral
ESP 12º	Group phase	1	16,6%	4	66,6%	1	16,6%	6	Neutral
	Main round + Final phase	0	0%	0	0%	0	0%	0	Not used
	Total	1	16,6%	4	66,6%	1	16,6%	6	Neutral
SLO 13º	Group phase	0	0%	0	0%	0	0%	0	Not used
	Main round + Final phase	No Main round							
	Total	0	0%	0	0%	0	0%	0	Not used
POL 14º	Group phase	1	33,33%	1	33,33%	1	33,33%	3	Neutral
	Main round + Final phase	No Main round							
	Total	1	33,33%	1	33,33%	1	33,33%	3	Neutral
CZE 15º	Group phase	0	0%	0	0%	0	0%	0	Not used
	Main round + Final phase	No Main round							
	Total	0	0%	0	0%	0	0%	0	Not used
CRO 16º	Group phase	0	0%	0	0%	0	0%	0	Not used
	Main round + Final phase	No Main round							
	Total	0	0%	0	0%	0	0%	0	Not used
Championship total		30	37,5%	41	51,25%	9	11,25%	80	Neutral

Mean per team	1,88	37,5%	2,56	51,25%	0,56	11,25%	5	Neutral
Minimum per team & % of the total	0	0%	0	0%	0	0%	0	Not used
Maximum per team & % of the total	7	35%	11	55%	2	10%	20	Neutral

Note. **Positive:** the highest percentage corresponds to a positive result, or there is equality between the positive and neutral percentage. In the latter, it is considered positive because a neutral result neither favors nor harms, so the positive result prevails. **Neutral**: the highest percentage corresponds to a neutral result, or there is an equality between positive and negative. **Negative**: the highest percentage corresponds to the negative result, or there is equality between neutral and negative that, for the same reason as before, the negative result prevails.

Table 3. Influence on the partial score of each empty goal situation in 7 vs. 6 by teams and phase of the 2020 championship.

Teams	Phase of championship	Influence on the partial score of each empty goal situation in 7 vs 6							Final balance
		Positive result		Neutral result		Negative result		Total	
		n	% del total	*n*	% del total	*n*	% del total	*n*	
NOR 1º	Group phase	0	0%	0	0%	0	0%	0	Not used
	Main round + Final phase	0	0%	0	0%	0	0%	0	Not used
	Total	0	0%	0	0%	0	0%	0	Not used
FRA 2º	Group phase	0	0%	2	100%	0	0%	2	Neutral
	Main round + Final phase	3	33%	5	56%	1	11%	9	Neutral
	Total	3	27%	7	64%	1	9%	11	Neutral
CRO 3º	Group phase	0	0%	0	0%	0	0%	0	Not used
	Main round + Final phase	0	0%	0	0%	0	0%	0	Not used
	Total	0	0%	0	0%	0	0%	0	Not used
DEN 4º	Group phase	4	44%	5	56%	0	0%	9	Neutral
	Main round + Final phase	0	0%	2	100%	0	0%	2	Neutral
	Total	4	36%	7	64%	0	0%	11	Neutral
RUS 5º	Group phase	0	0%	0	0%	0	0%	0	Not used

	Main round + Final phase	2	100%	0	0%	0	0%	2	Positive
	Total	2	100%	0	0%	0	0%	2	Positive
NED 6º	Group phase	0	0%	0	0%	0	0%	0	Not used
	Main round + Final phase	0	0%	0	0%	0	0%	0	Not used
	Total	0	0%	0	0%	0	0%	0	Not used
GER 7º	Group phase	0	0%	0	0%	0	0%	0	Not used
	Main round + Final phase	0	0%	0	0%	0	0%	0	Not used
	Total	0	0%	0	0%	0	0%	0	Not used
MNE 8º	Group phase	10	56%	6	33%	2	11%	18	Positive
	Main round + Final phase	3	43%	1	14%	3	43%	7	Neutral
	Total	13	52%	7	28%	5	20%	25	Positive
ESP 9º	Group phase	0	0%	2	100%	0	0%	2	Neutral
	Main round + Final phase	0	0%	0	0%	0	0%	0	Not used
	Total	0	0%	2	100%	0	0%	2	Neutral
HUN 10º	Group phase	0	0%	0	0%	0	0%	0	Not used
	Main round + Final phase	0	0%	0	0%	0	0%	0	Not used
	Total	0	0%	0	0%	0	0%	0	Not used
SWE 11º	Group phase	0	0%	1	100%	0	0%	1	Neutral
	Main round + Final phase	1	33%	1	33%	1	33%	3	Neutral
	Total	1	25%	2	50%	1	25%	4	Neutral
ROU 12º	Group phase	0	0%	0	0%	0	0%	0	Not used
	Main round + Final phase	2	100%	0	0%	0	0%	2	Positive
	Total	2	100%	0	0%	0	0%	2	Positive
SRB 13º	Group phase	28	44%	25	39%	11	17%	64	Positive
	Main round + Final phase	No Main round							
	Total	28	44%	25	39%	11	17%	64	Positive

POL 14º	Group phase	8	57%	5	36%	1	7%	14	Positive
	Main round + Final phase	No Main round							
	Total	8	57%	5	36%	1	7%	14	Positive
CZE 15º	Group phase	0	0%	0	0%	0	0%	0	Not used
	Main round + Final phase	No Main round							
	Total	0	0%	0	0%	0	0%	0	Not used
SLO 16º	Group phase	6	60%	3	30%	1	10%	10	Positive
	Main round + Final phase	No Main round							
	Total	6	60%	3	30%	1	10%	10	Positive
Championship total		67	46,21%	58	40%	20	13,79%	145	Positive
Mean per team		4,19	46,21%	3,63	40%	1,25	13,79%	9,06	Positive
Minimum per team & % of the total		0	0%	0	0%	0	0%	0	Not used
Maximum per team & % of the total		28	43,75%	25	39,06%	11	17,19%	64	Positive

Note. **Positive:** the highest percentage corresponds to a positive result, or there is equality between the positive and neutral percentage. In the latter, it is considered positive because a neutral result neither favors nor harms, so the positive result prevails. **Neutral**: the highest percentage corresponds to a neutral result, or there is an equality between positive and negative. **Negative**: the highest percentage corresponds to the negative result, or there is equality between neutral and negative that, for the same reason as before, the negative result prevails.

Figure 2 shows a comparison of the frequency of use and effectiveness of 7 vs. 6, with the data grouped according to their results in: positive result (scoring a goal), neutral result (without scoring or receiving a goal), and negative result (receiving goal by counterattack or by a quick goal throw-off), in each championship.

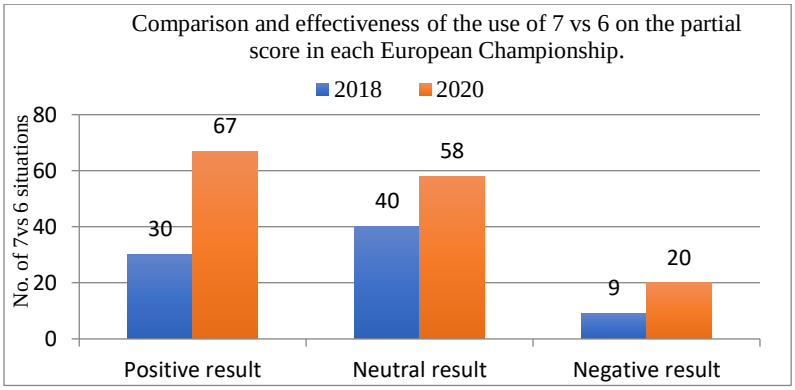

Figure 2. Influence of the use of 7 vs. 6 on the partial score in each championship.

Figure 3 shows the frequency of use and effectiveness of the 7 vs. 6 per team in each championship.

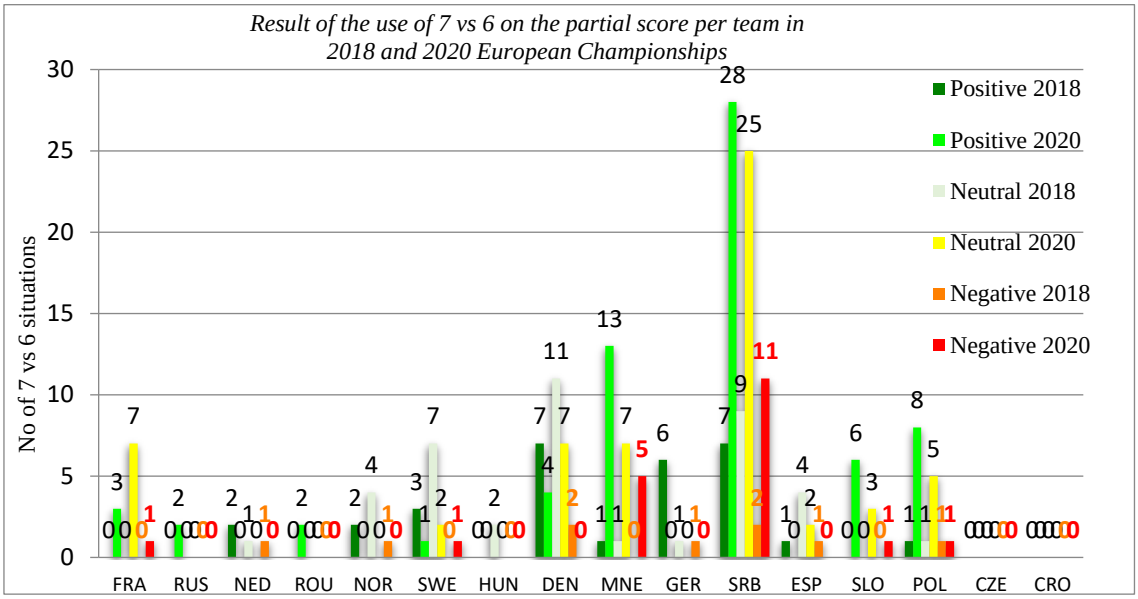

Figure 3. Influence of the use of empty goal 7 vs 6 on the partial score of each team in 2018 and 2020 European Women's Handball Championships.

Conclusions

- The tactical resource of empty goal in 7 vs 6 attack situations has a much higher frequency of use in 2020 championship than in 2018, almost doubling its use, going from 80 occasions in 2018 to 145 in 2020.
- The positive results that occur on the partial score when using this tactical resource of 7 vs 6 in attack also doubled from the 2018 championship (30) to that of 2020 (67), with the positive results prevailing in 2020 compared to the neutral or negatives.
- The team that most frequently uses this tactical resource is Serbia, with a neutral balance in 2018 and positive in 2020, and Croatia does not use it in any championship.

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COURT SHUTTLE TEST IN YOUNG JAPANESE FEMALE HANDBALL PLAYERS: RELATIONSHIP WITH PHYSICAL FACTORS AND A COMPARISON AMONG DIFFERENT AGE CATEGORIES

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Summary

We conducted a survey of young Japanese female handball players of different age categories to clarify the relationship between the Court Shuttle Test (CST) and the physical factors necessary for success in handball. Study results indicate that measuring the CST may be used to evaluate the intermittent running ability of young female handball players.

Keyword: handball, intermittent ability, Court Shuttle Test, aerobic capacity, young female players

Introduction

Handball is a fast and physical sport which requires both aerobic and anaerobic endurance (Delamarche et al. 1987, Rannou et al. 2001). Players with high aerobic and anaerobic endurance are able to perform quick actions and sprints without getting fatigued, which has a crucial impact on match results. The game of handball is composed of repeated sprints such as fast breaks and quick counter attacks which require great aerobic capacity. Players with greater aerobic capacity tend to show lower fatigue index, which shows a negative correlation in handball players (Balasubramanian & Chittibatu. 2014, Chittibabu 2014).

To select handball players who can compete at the international level, the Japan Handball Association (JHA) created physical strength tests for young players (2009 National Training System). However, there are no tests to assess aerobic capacity or intermittent exercise. In 2014, the Japanese women's national handball team began to incorporate and validate the Court Shuttle Test (CST) into their training program. The CST is a high-intensity anaerobic repetition exercise, which participants perform twice, and the results of the second test indicated that it could also be used to evaluate aerobic capacity (Ito et al.2017). However, there are few studies on the CST in regards to young handball players. In addition, few studies have investigated the relationship between the CST and the physical factors necessary for handball.

We conducted a survey of different age categories to clarify the relationship between the CST and the physical factors necessary for handball. The objective of this study was to observe the

correlation between young female handball players' ability to intermittent speed endurance and success on the handball court.

Method

Subjects:

The subjects were 30 elite young Japanese female handball players (U18 players: n=14 and U15 players: n=16) who participated at either the national high school or junior high school championship level. We compared two groups in different age categories. Written explanations of the purpose, measurement items, and measurement methods were distributed to all participants, and their consents were obtained. Consents were also obtained for the use of the participant's individual measurement data.

Physical performance tests:

The following four tests were conducted: the Court Shuttle Test (CST), the 30m Straight Sprint test (30mSS), the Standing Long Jump (SLJ), and the 20m Shuttle Running test (20mSR). The CST required players to repeatedly run at full speed throughout 6 turns totaling 280m on a 40-m court (1st time: CST1). After a 2-min rest, they repeated the process (2nd time: CST2). In addition, the total time of the CST (TT) and delay time of the CST (DT) were calculated from the CST1 and CST2 and compared (Fig.1).

Statistical analysis:

All data are presented as mean ± SD. The Pearson product-moment correlation coefficient was used to calculate the correlation between the results of the straight sprint, jumping ability, aerobic capacity, and the Court Shuttle Test. The unpaired t test was used to compare the results for U18 players with those for U15 players. Statistical significance of the test results was set at 5%.

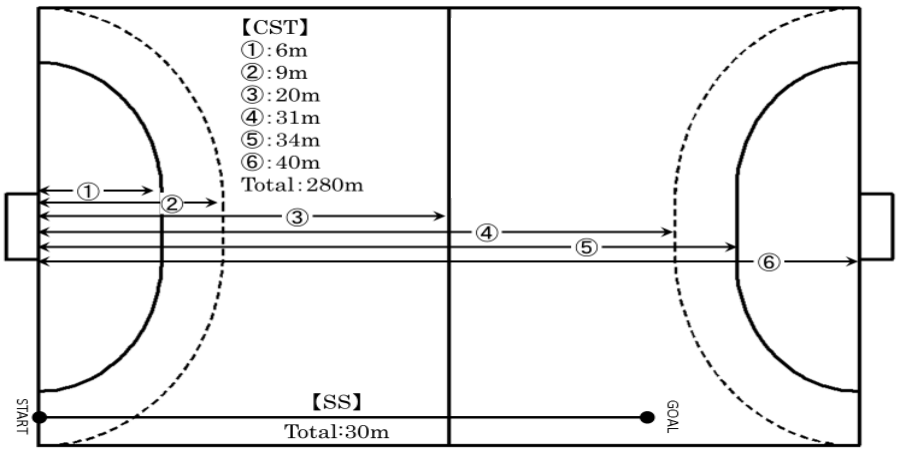

Figure 7 Court shuttle test

Results and Discussion

Tables 1 and 2 show the physical characteristics and the results of the physical performance tests of the subjects, respectively. Weight and BMI were significant higher in U18 players. There were no significant differences in height between the two groups. The average height and weight of the U15 and U18 players who participated in the Japan Handball Association National Training System (NTS) Center Training from 2010 to 2012 were 166.7 ± 5.1 cm and 168.8 ± 4.6cm, respectively, and 58.7 ± 6.3 kg and 62.7 ± 6.3 kg, as reported by Moriguchi et al. (2013). Compared with this previous study, young female handball players in this study were shorter and lighter.

Table 1 Physical characteristics of young female handball players

	U18 players	U15 players	Significance level
Height (cm)	161.0±5.41	161.1±5.30	ns
Weight (kg)	56.1±3.98	50.7±4.61	**
BMI	21.6±1.04	19.5±0.92	**

Values are mean ± S.D. *p<0.05, **p<0.01, ns: not significant

Table 2 Physical performance tests of young female handball players

	U18 players	U15 players	Significance level
30m sprint (sec)	4.76±0.23	4.88±0.23	ns
Standing long jump (cm)	210.7±11.07	201.5±7.66	*
20m shuttle run (no. of times)	106.07±11.59	90.5±14.36	**

Values are mean ± S.D. *p<0.05, **p<0.01, ns: not significant

The comparison between U18 and U15 players showed that U18 players was jumped further than U15 players, as demonstrated by the SLJ ($p<0.05$). There were no significant differences in the 30mSS between the two groups. According to Moriguchi et al. (2013), there was no difference in sprint ability between U15 and U18 players who participated in the NTS Center Training, and U18 players were significantly better in terms of their jump performance. The same result was observed in this study. The average of the U15 and U18 players who participated in the NTS Center Training were 5.22 ± 0.39 sec and 5.28 ± 0.34 sec, respectively in the 30mSS, and 209.7 ± 19.0 cm and 204.4 ± 12.4 cm in the SLJ, as reported by Moriguchi et al. (2013). Compared with this previous study, young female handball players in this study were faster than the elite players of the same age category and had similar jumping ability.

On the other hand, 20mSR, a measure of aerobic capacity, was significantly better in the U18 players than in the U15 players ($p<0.01$). The estimated maximal oxygen uptake from performing the 20m shuttle run test (Leger et al.1982) was 49.9 ± 2.61 ml/kg/min in the U18 players and 46.4 ± 3.23 ml/kg/min in the U15 players. According to Ikeda et al. (2007), the estimated maximal oxygen uptake of Japanese elite university female handball players was 46.3 ± 3.07 ml/kg/min. Compared with this previous study, the estimated maximal oxygen uptake of the U18 players in this study was greater than that of the university players, who scored nearly the same as the U15 athletes. These results show that the young handball players in this study tend to have a greater anaerobic capacity for moments such as sprinting and jumping, as well as a greater aerobic capacity.

The results of the Court Shuttle Test are shown in Table 3. U18 players performed better than U15 players, as demonstrated by the CST1 ($p<0.01$), the CST2 ($p<0.05$) and the TT ($P<0.05$). There were no significant differences in the DT between the two groups. Ito et al. (2017) reported that the average CST1 and CST2 of the Japan national team players were 59.9 ± 2.4 sec and 64.3 ± 2.9 sec, while those of the university players were 65.5 ± 4.1 sec and 70.6 ± 4.3 sec, respectively. Compared with this previous study, U18 players in this study were slower than the Japan national players in both CST1 and CST2, but faster than university players. And the U15 players had almost the same values as university players in both CST1 and CST2. As for the DT, the U18 players and U15 players were less than the national players' DT of 5.5 ± 2.3 sec (Ito et al. 2017). These results suggest that the young female handball players in this study had excellent intermittent speed endurance.

Table 3 Court shuttle test of young female handball players

	U18 players	U15 players	Significance level
1st CST (sec)	61.21±3.07	64.44±2.37	**
2nd CST (sec)	66.56±3.46	69.06±3.23	*
Total Time (sec)	127.71±6.40	133.50±5.38	*
Delay Time (sec)	5.29±1.33	4.63±1.78	ns

Values are mean ± S.D. *$p<0.05$, **$p<0.01$, ns: not significant

A significant correlation was observed between the CST1 and the 30mSS in the two groups (U18: r= 0.667, U15: r= 0.645). Moriguchi et al (2009), demonstrated a significant correlation was observed between the 40-m sprint test and the 400m anaerobic running test. These results indicate a strong relationship between sprint ability and speed endurance. However, no significant correlation was observed between the CST2 and the 30mSS (U18: r= 0.405, U15: r= 0.373). These indicate that 30mSS, a measure of anaerobic capacity, has a lower relationship with CST2, which means that CST2 is influenced by other fitness factors (Fig. 2).

A significant correlation was observed between the CST1 and the 20mSR in the two groups (U18: r= -0.604, U15: r= -0.737). There was also a significant correlation between the CST2 and the 20mSR (U18: r= -0.757, U15: r= -0.869). It is particularly interesting that 20mSR, an

index of aerobic capacity, showed an extremely high correlation with the CST2. Ito et al (2017), demonstrated a significant correlation was observed between the CST1 and the CST2 and the 12-min running test, with the CST2 having a stronger correlation to the 12-min running test than the CST1. The fact that the correlation between the CST2 and the 20mSR is stronger than the relationship between the CST1 and the 30mss indicates that the CST2 is more dependent on aerobic capacity. These results suggest that the greater the aerobic capacity, the better the performance in the CST2 (Fig. 3).

A significant correlation was observed between the delay time of the CST, an index of ability for recovery, and the 20mSR in both groups (U18: r= -0.577, U15: r= -0.597). However, no significant correlation was observed between the DT and the 30mSS (U18: r= -0.225, U15: r= -0.177). Tanaka et al (1997). reported that superior aerobic capacity is necessary to maintain anaerobic exercise at the end of intermittent exercise. In addition, the players with greater aerobic capacity tend to show lower fatigue index, which shows a negative correlation in handball players (Chittibabu 2014). In other words, the greater the aerobic capacity, the more successful the recovery.

A significant correlation between the total time of the CST and the 20mSR was observed (U18: r= -0.698, U15: r= -0.597). These results indicate that TT is dependent on aerobic capacity. Suzuki et al. (2013, 2017) reported that female handball players who won the national championships in Japan (U18 and U15) needed not only anaerobic capacity but also excellent aerobic capacity. A good level of general fitness combined with a high aerobic and anaerobic capacity form the foundation for success in handball (Delamarche et al. 1987). These findings show that repeated measurement of the CST enables not only the measurement of the aerobic capacity of female handball players but also the assessment of their sprint performance, speed endurance and intermittent running ability.

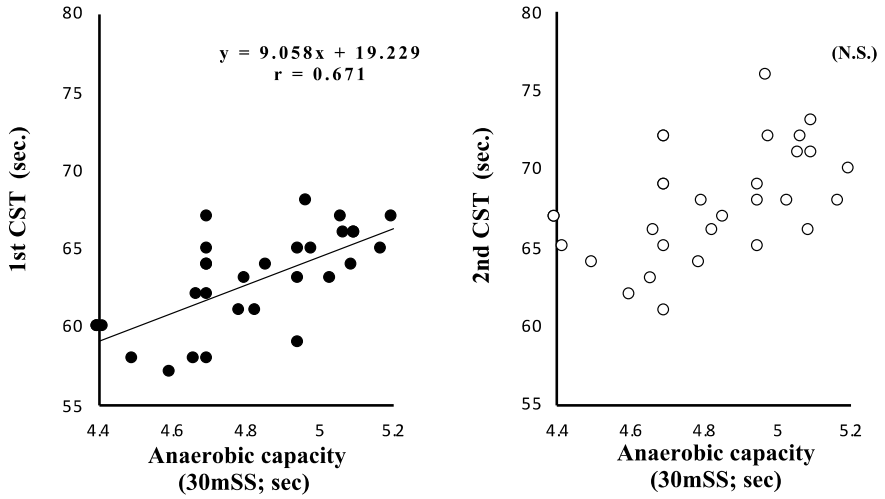

Figure 8 Relationship between Anaerobic capacity and CST performance of the young female handball players

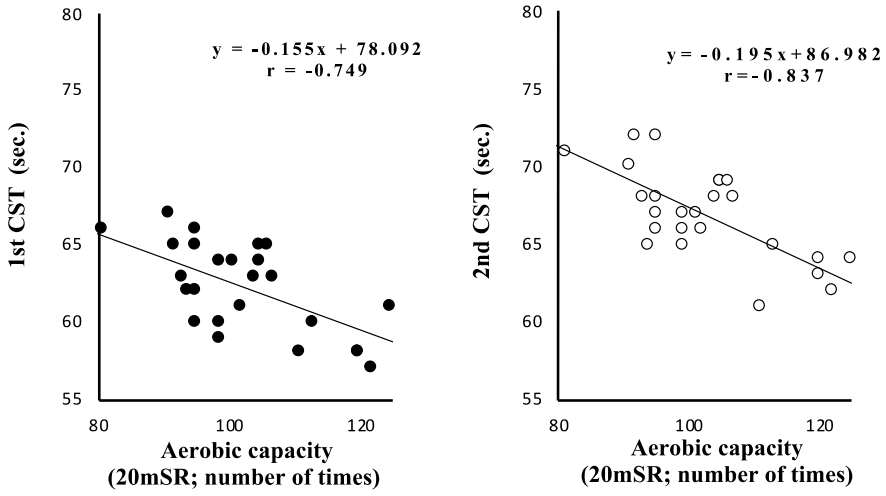

Figure 3 Relationship between Aerobic capacity and CST performance of the young female handball players

The Japanese National Training System (NTS) has been without a test to assess aerobic or intermittent exercise for a long time. In 2014, the Japanese women's national handball team began to incorporate and validate the court shuttle test into their training program. The CST is

considered a valid method to assess various physical factors of athletes, including the aerobic capacity of young female handball players. The CST may also be used as a useful method to scout talented players.

Conclusion

In this study of young female handball players, we found that as the ages of the participants rose, results of the CST became significantly faster. A correlation between the CST and the physical factors necessary for handball, especially aerobic capacity, was also observed.

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KINEMATIC ANALYSIS OF THROWING FOR HANDBALL PLAYERS: THE DIFFERENCE BETWEEN USING THE NAIL PROTECTOR AND OWN NAILS

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Summary

Due to improve the throwing performance we verify the effect of applying nail protectors on the throwing motion. we to improve the throwing performance. As the results, it was revealed that the external rotation of shoulder while applying the nail protectors showed significantly greater ROM than while not applying them at the moment of the Stride Foot Contact as the result of analyzing the series of the throwing motion on each phase.

Keywords: handball, nail protector, throwing performance, kinematic analysis, ROM

Introduction

Nails have the effect of holding the force added from the ventral surfaces of the digits. Regarding to the anatomical point of view, the distal ends of phalanxes do not reach to the distal ends of nail plates, the force added from the ventral surfaces of the digits, therefore, is held by nails only (Higashi, 2016). Because of that, it is believed that nails have the impact on the athletic performance, especially under the circumstance of being susceptible to the external force such as the sports. It is known that a protective coat is actually used by baseball pitchers for preventing from breaking nails while throwing a ball and by wrestlers for improving performance while grasping an opponent. Theoretically it seems that the gel nails have effect on injury prevention and gripping force, there is however, lack of objective data for proving them. From above reasons, the authors examined the relationship between the force added from the ventral surfaces of the digits and the distorted shape of nails while gripping a cone and a sphere object, and they reviewed the usability of applying the protective coat on nails at The Japan Society of Mechanical Engineers 2020 and SHD 2020. As the result, it was revealed that the protective coat tended to reduce the degree of distortion for the shape of nails. Based on the basic research, this study which was recognized as a next step examined how the protective

coat on nails influence the throwing motion and the muscular activities on the forearm while throwing a handball.

Methods

In this study, it was examined the effect of applying the protective coat on the throwing motion and the muscular activities while throwing a handball. For examining the usability of applying the protective coat, each subject performed throwing handballs under two conditions (with and without applying the three-layered protective coat on nails), and the throwing motions and the muscular activities were collected and analysed.

Subjects:
Three collegiate men's handball players (Age: 19.67±1.53yr, Height: 174.67±5.51cm, Weight: 72.67±5.03kg) who played at the 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 subjects in writing, and the agreements from all subjects were collected prior to the experiment. The permission from all subjects to use the collected data for the presentation were also obtained prior to the experiment.

Condition of throwing:
After enough warming up, all subjects performed the straight shot by the three speeding-up steps with their maximum efforts at the distance of 5m from the target. For focusing on the differences of the throwing motion with and without applying the protective coat on nails and examining the usability of applying them, each subject performed throwing handballs under two conditions (with and without applying the three-layered protective coat on nails). All subjects performed 3 throwing trials on each condition. The extra throw was allowed in the case if a subject was not satisfied the throw. Furthermore, it was avoided using the sticking gel or sticking tape because the study focused more on examining the usability of applying the protective coat on nails even these gel or tape improved the gripping force for holding a ball when throwing a handball.

Recording the throwing motion and collecting data:
In order to reveal the difference of throwing motions between two conditions of with or without applying the protective coat, shoulder, elbow, and wrist joints at each throwing motion were recorded by the three-dimensional motion capturing system with sampling frequency at 200Hz.

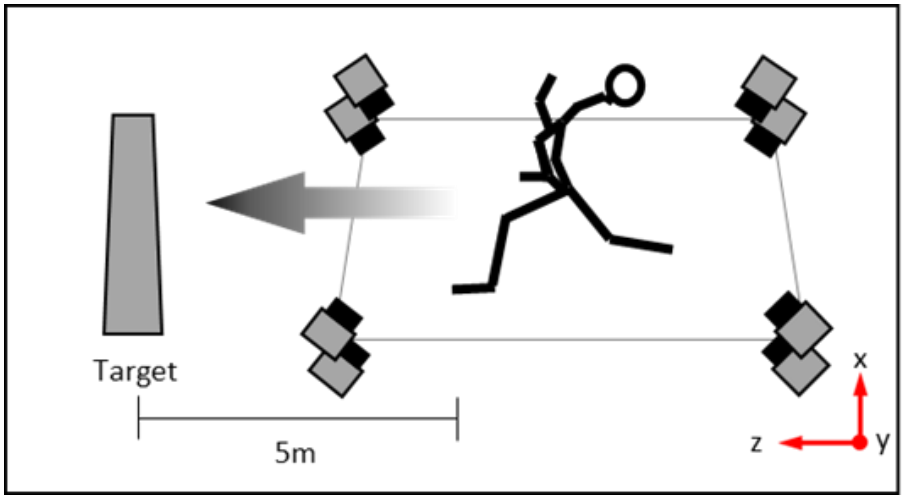

Fig.1 The layout of experiment for throwing. A subject throw a handball towards the target. A distance from the subject to the target was 5m. Four video cameras were set to each corner.

Analysis of the throwing motion:

According to the previous study, it was reported that there was an increase in ROMs for the maximum external rotation of shoulder, the maximum flexion of elbow, and the maximum extension of wrist (Ito et al., 2019). The ROMs for each joint, therefore, were analysed in this study. Moreover, the series of throwing motion for handball were applied to the series of pitching phase for analysing the throwing motion in detail (Hirayama, Fujii, Ae, & Koike, 2008) (Figure2), and the angle of the external rotation of shoulder was analysed at the points where a stride foot touched a ground (Stride Foot Contact: SFC), throwing arm reached to the maximum external rotation (Maximum shoulder External Rotation: MER), and a ball was released from a throwing hand (Release: REL).

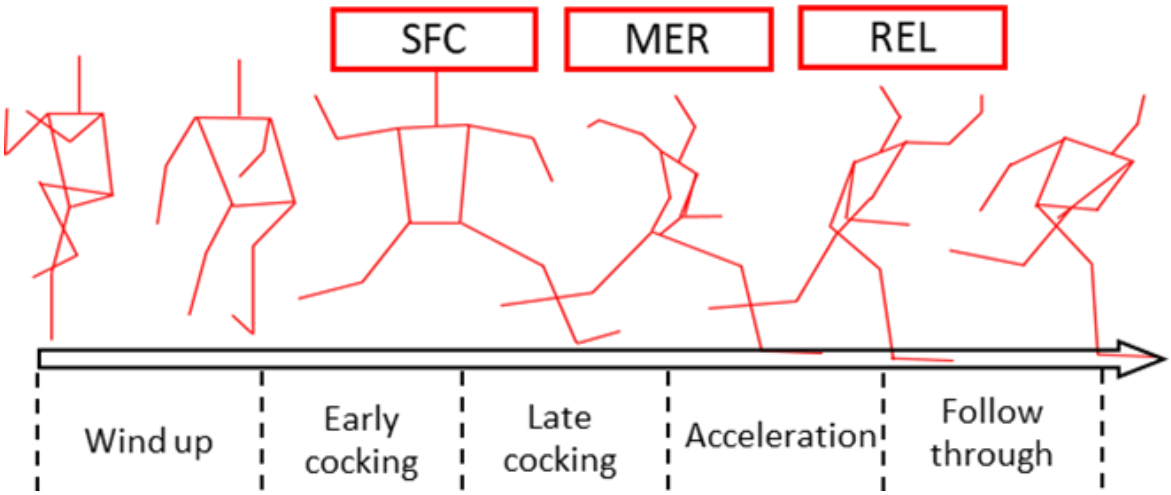

Fig.2 The definition of the pitching phase.

Result and Discussion

Comparing the maximum angles of each joint while throwing (With and without applying the protective coat):
Figure 3 showed the average and the standard deviation (SD) for the maximum angles of the external rotation of shoulder, the flexion of elbow, and the extension of wrist from one of subjects.

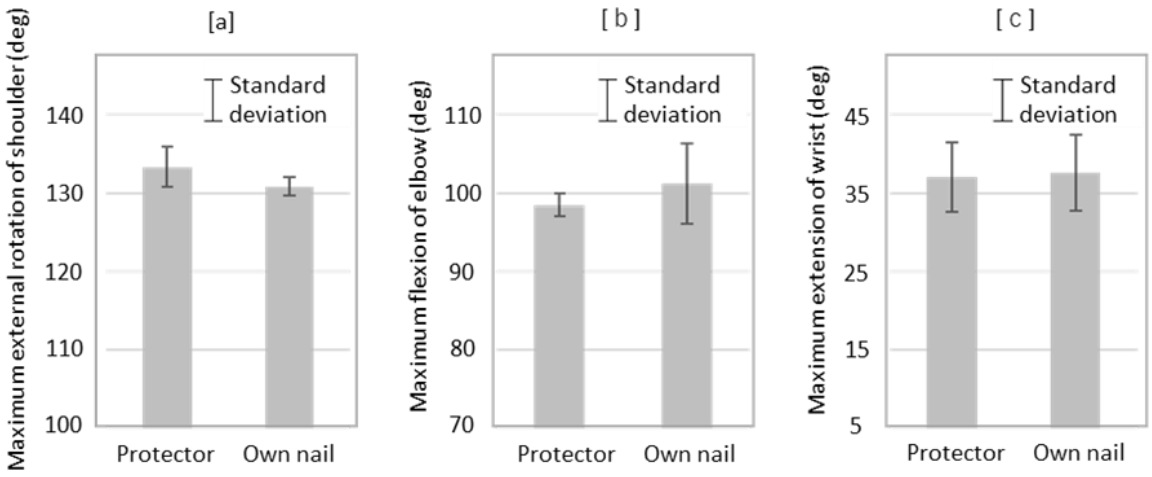

Fig.3 ROMs for maximum external rotation of shoulder, Maximum flexion of elbow and Maximum extension of wrist

There was no significant difference between the conditions with and without applying the protective coat on nails. The other subjects also showed the similar result.

Comparing the maximum angles of the external rotation of shoulder on each phase of throwing (With and without applying the protective coat):
Figure 4 showed the transitions of the angle for the external rotation of shoulder while throwing a handball at the two conditions of with and without applying the protective coat. The line graph showed the external rotation of shoulder for the SFC at the starting point, the MER of shoulder at the maximum value, and the external ration of shoulder for the REL at the end point. The full line represented the data of applying the protective coat, the dotted line represented the data of not applying the protective coat, and each trial was classified by color. Moreover, Figure 5 showed the average and the SD for the angles of the external rotation of shoulder from each subject.

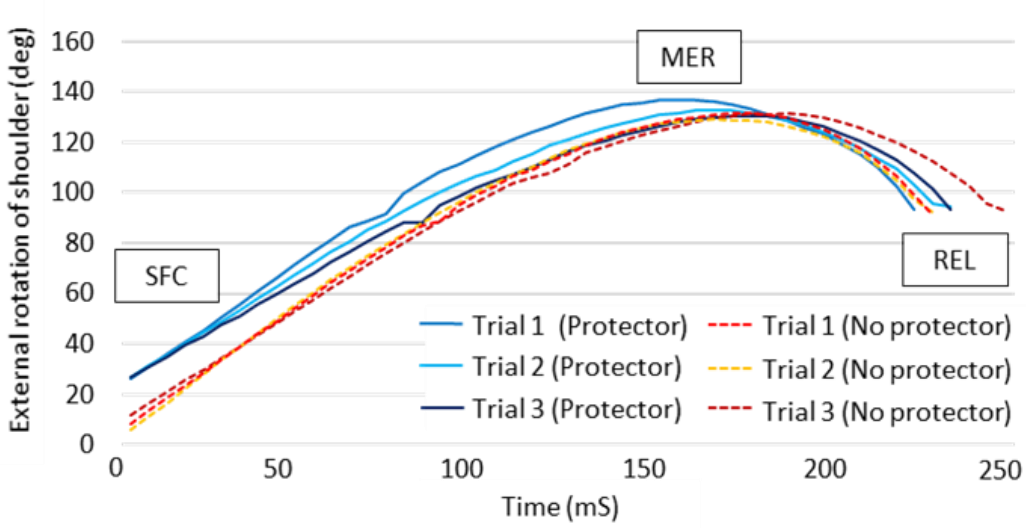

Fig.4 The transitions of ROMs for external rotation of shoulder. The full line represented the data of applying the protective coat, the dotted line represented the data of not applying the protective coat, and each trial was classified by color.

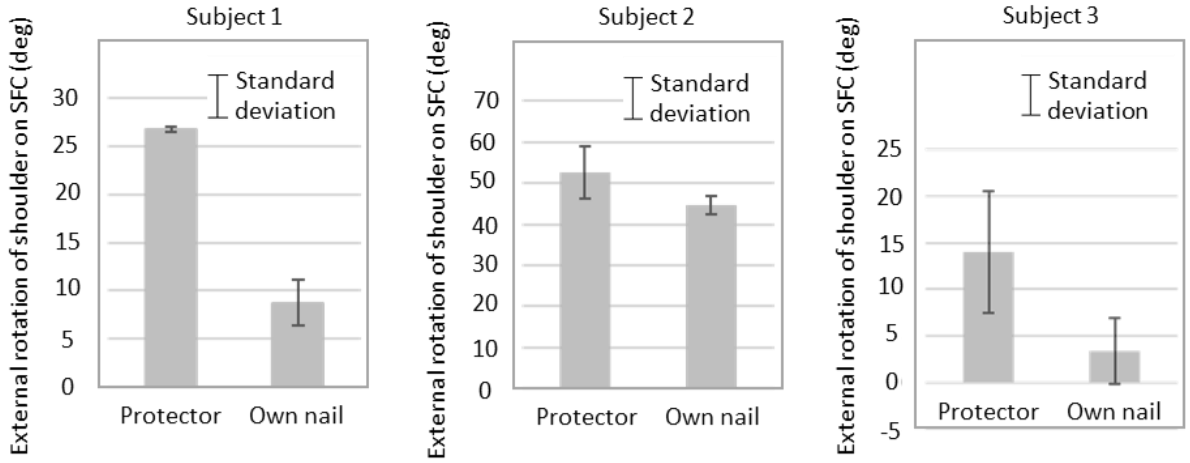

Fig.5 The average and the SD for the angles of the external rotation of shoulder from each subject at SFC.

As a result of analysing each phase for the series of the throwing motion, there was an increase in ROMs for the external rotation of shoulder at the SFC while applying the protective coat on nails as shown in Figure 5. There was no significant difference for subject 2, however it was believed that the protective coat had some effects on the other subjects. From these results, it was assumed that the gripping force to hold a handball improved due to decreasing the degree of the distorted nails because of applying the protective coat. From the perspective of the throwing performance, it was also reported that the release point of a ball was disturbed due to the delay of swinging the arm after rotating the lumbar spine when the shoulder joint had not changed over from the internal rotation to the external rotation at the SFC. Moreover, from the

perspective of the injury prevention, it was reported that the delay of changing over to the external rotation of the shoulder tended to lower the involved elbow, the mechanism gave the excessive valgus force to the elbow, and it led the elbow to the functional disorder (Takagi et al., 2014). Based on these factors, it was suggested that to apply the protective coat on nails potentially not only improved the throwing performance but also prevented the functional disorder.

Conclusion

This study examined how the protective coat on nails influence the throwing motion and the muscular activities on the forearm while throwing a handball. As a result of analysing the throwing motion, it was suggested that there was an increase in ROMs for the external rotation of shoulder at the SFC while applying the protective coat on nails, and to apply the protective coat on nails potentially contributed not only to improve the throwing performance but also to prevent the functional disorder.

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DIFFEREENCE PLAYERS DURING CRUNCH TIME IN CLOSE HANDBALL MATCHES – AN ANALYSIS OF THE OLYMPIC HANDBALL TOURNAMENT ON A PLAYERSCORE BASIS

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The team of authors looked at the course of close games at crunch time when analysing the handball tournament during the 2021 Summer Olympics. Of the 38 games in the overall tournament, 15 games were still close 5 minutes before the end of the game, means the difference in the score was no more than 2 goals apart! In such situations, the same players always show up who are responsible for the outcome of the game.

Introduction

All 12 participating nations played close games. A first proof of how close the top of world handball is, especially in an Olympic tournament with 12 qualified teams - in comparison, the 2021 World Cup in Egypt had 32 participants. However, there was not a single draw and any resulting extra time in knockout matches in the main round in Tokyo! The most matches that were decided only in the final phase were played by Spain (5), followed by Denmark (3) and France (3) as well as Sweden (3). Germany, Norway, Egypt, Portugal and Bahrain were also twice in the situation of having to lead games with very close outcomes.

In total, 71 goals were scored in the 15 identified matches, an average of 0.52 goals per minute (in the last 5 minutes in close matches). In all 38 games together, however, 230 goals were scored in the last 5 minutes, means 1.21 goals per minute, when there was no fight to the end to win or lose. So the goals were scored more than twice as fast. Looking at the total playing time over the entire course of the tournament, with 2,204 goals, a goal was scored almost every minute (0.97 goals per minute). This is an indication that the close games are tactical in nature, with some teams playing against each other that are evenly matched at times. Easy, quick goals and superior situations are rarely seen in the final phase in the games studied! Egypt against Denmark (27:32) from the preliminary round could be cited as the most likely exception. In addition, outstanding goalkeeping performances came into play in decisive phases of the game, as presented to the spectators by Vincent Gérard (FRA), Niklas Landin (DEN) or Gonzalo Pérez de Vargas (ESP) or Karim Hendawy (EGY)!

In the following, only the medal winners of the 2021 Olympic handball tournament in Tokyo will be looked in more detail at France as the winner of the gold medal, Denmark as the silver medal winner as well as Spain as the third-placed team, which prevailed over Egypt in the "small" final.

France only ever scored 2 goals in the 3 close matches during crunch time! In the preliminary round against Germany (30:29) as well as against Norway (29:32) and in the final against Denmark (25:23). France was the winner against Germany and Denmark. In each of these games, France led with 5 minutes to go, so that 2 conceded goals always kept them in the lead. Against Norway, however, France was 2 goals behind with 5 minutes to go (27:29) and after conceding 3 goals in the crunch time, lost rather clearly in the end with 32:29.

While France scored an average of 32 goals in the course of the tournament, this goal yield was never reached in close games against equal opponents. Especially in the final phase, the goals were scored after extra time (see Table 1). While France scored about every 2 minutes during the tournament, they never scored more than 2 goals (0.40 goals per minute) in the last 5 minutes in close games.

Denmark also had 3 very close games to lead. The final against France (see above), the semi-final against Spain (27:23) and the preliminary round match against Egypt (32:27). In these games, the Danes scored only 2 goals against France in crunch time - which was not enough to win - but 4 goals each against Spain and Egypt. At the same time they conceded 3 goals against France, but only 2 goals against Spain and only 1 goal (!) in the last 5 minutes against Egypt.

The Danes also struggled to reach their tournament average goal total in close games (see Table 1). In close games, the Danes tended to concede fewer goals than the tournament average (see Table 2). Unlike France, Denmark scored more quickly in the closing stages of close games, which may also be due to the tactical approach of the 7th outfield player. In the course of the 3 close games they conceded a total of 7 goals - just like the French - but scored 10 goals - France only 6 goals!

Spain struggled through 5 close games in which one team was only in front by a maximum of 2 goals with 5 minutes to go! Against Germany (28:27) and against Norway (28:27) in the preliminary round, against Sweden (34:33) in the quarter-finals, against Denmark (see above) in the semi-finals and against Egypt (33:31) in the match for 3rd place.

4 games were won, the semi-final against Denmark finally lost. Against Germany, the Spaniards scored 3 times and conceded only 2 goals, in the game against Egypt they were successful 4 times and had to concede 3 goals, against Denmark Spain scored only 2 times in the final phase and had to concede 4 goals, in the game against Norway 2 goals were enough to bring the 26:24 lead over time with 3 goals against. It was the same in the game against Sweden, where a 2 goal lead 5 minutes before the end of the game was enough to leave the court as the winner with 2 goals scored and 3 conceded.

Spain is between the French and the Danes in crunch time scoring. On the other hand, Spain scored the fewest goals of the 3 medal winners on average during the tournament and at the same time conceded the most goals in this 3's comparison, which is also confirmed in the crunchtime for goals conceded.

Methods

Who were the decision-makers and difference-makers in the world's best teams at the Tokyo Olympics? For this purpose, further analysis makes use of the PlayerScore. The PlayerScore is a utility model for calculating the value a player has. Be it as a personal share to the game or cumulatively for the team in the course of a game or tournament. The PlayerScore is one of two indices in use in Germany. The other is the Handball Performance Index (HPI) from the Handball Bundesliga (HBL). The PlayerScore is therefore a quantitative procedure that is objectively oriented to existing numerical values that are collected by the organising world association, the International Handball Federation (IHF)!

The PlayerScore includes positive factors such as goals, assists, penalty throws, blocked throws and ball wins in defence. Negative factors include missed throws, technical errors, ball losses, time penalties, penalty throws caused and red cards. These actions are weighted according to goal difference and playing time, so that the total score is calculated from 2 weighted sums! One weighting is done with a minute function, where each action is scored according to the minute played. The other weighting is done with a goal difference function, where each of the above actions is scored with the current goal difference at the time of the game. The time weighting results in actions at the beginning of a match having less impact than actions at the end of a match. The goal difference weighting means that actions with a close score between the two teams are rated as more serious than actions with a large goal difference, i.e. when the game is supposedly already decided.

When weighting individual parameters, one has to say goodbye to the previous informative value of already known statistics. Inevitably, a different ranking will be formed than with the unweighted sum of values added together (cumulative calculation), which can be read, for example, in the list of goal scorers, the scoring rate, the sum of missed shots, the catch rate of balls held, the seven-metre saves and seven-metre scorers as well as in the time penalty register, and which to date have stood side by side without any connection.

Hypotheses in the research process

Two hypotheses were formulated to gain further insights:

1) It can be assumed that in handball games with a close score, the same players are always brought into action shortly before the end of the game.

2) It can also be assumed that these are the players who had the greatest value for their teams throughout the tournament.

Results

In the case of the gold medal winners France, 9 different field players came into focus in the last 5 minutes of close matches. This testifies to the incredibly broad and balanced quality in the team. In the 3 close matches, only Dika Mem, Nikola Karabatic, Ludovic Fabregas and

Hugo Descat were repeatedly or repeatedly in action on the field - with varying degrees of success.

For silver medallists Denmark, 8 different players made their mark on the game in crunch time. It is clear that Mathias Gidsel, who was named Most Valuable Player (MVP), played a major role in the success in all three games. But it is also clear that there is a pattern in the squad composition. Mikkel Hansen, Mads Mensah Larsen, Mathias Gidsel are always the decision makers in such close games, take responsibility and are therefore always involved in the outcome of the game.

For bronze medallists Spain, 12 different players made an appearance in crunch time. Alex Dujshebaev in all games, although not always to his team's advantage. Aleix Gomez, Gedeon Guardiola and Adrian Figueras were also called upon relatively often, namely in 3 games in crunch time! It is striking that Raul Entrerrios was only called into action in 2 of the 5 very close games.

The facts described above lead us to a qualitative investigation. What did the players listed do on the pitch in the last 5 minutes of the game to be successful with their team? What were the actions of the players listed above? Therefore the actions of left wing Hugo Descat (France), right wing Aleix Gomez (Spain), left back Mikkel Hansen (Denmark), circle player Ludovic Fabregas (France) as well as right back Mathias Gidsel (Denmark) as MVP should be looked at more closely from the All-Star Team! According to our analysis, Nedim Remili, who was nominated in the all-star team at centre back, appeared "only" once in the 3 close games of the French, but in a very positive way. He will not be considered further in the following. In detail:

Hugo Descat (LW)

In the France-Germany match, Hugo Descat converted a 7-metre penalty throw after 58:36 minutes at 29:28. At 30:28, it was almost clear - especially after the attacking and defensive effectiveness in close games described in Tables 1 and 2 - that the French should have thus at least secured a draw, even if Descat still missed a throw from outside left after 59:37 minutes of play. However, the score was still 30:28 with 23 seconds left in the game. Over the total playing time, Descat achieved a PlayerScore value of 15.77 against Germany and was thus the best player of his team in this preliminary round match, in which he was on the court for 30 minutes. Only German players Timo Kastening (23.57) and Steffen Weinhold (19.36) achieved higher PlayerScore values in the match, but not the win.

In France's tight preliminary round match against Norway, no match action was tracked on Descat. This confirms the variable line-up of the French even in close games and the balanced strong squad. Over the total playing time, Descat achieved a PlayerScore value of 14.64 with 46 minutes played against Norway and was once again the best player of his team. The opponents had better individual scores on the day - Kevin Gulliksen (18.16), Sander Sagosen (15.77) and Bjarte Myrhol (14.98) - but still the losers were Norway.

In the final between France and Denmark, Descat scored a goal from the left wing only after 56:55 minutes of play to increase the lead to 24:22 - after all! Over the total playing time,

Descat achieved a negative PlayerScore value of -1.61 against Denmark and was thus not a factor in his team's victory in this preliminary round match, in which Descat also played "only" 27 minutes!

At the end of the Olympic handball tournament, Hugo Descat had the fifth best PlayerScore value (78.12) with 215 minutes played in the 7 matches he played in. Due to the fact that Descat also takes the 7-metre penalty throws for his team and converts them with a lot of nerve, he prevailed over Remi Anri Doi (Japan) and Omar Elwakil (Egypt) at the outside left position. In the French team, Hugo Descat scored the second best behind Nedim Remili (89.31 PlayerScore points), followed by Ludovic Fabregas (68.92 PlayerScore points).

Aleix Gomez (RW)

In Spain's match against Germany, Aleix Gomez converted a 7-metre penalty throw after 55:13 minutes at 25:25. During the total playing time, Gomez achieved a PlayerScore value of 5.18 against Germany. He was actively involved in the game for 29 minutes and finally had the fifth-best PlayerScore value in his team in this preliminary round game.

In Spain's match against Norway, Aleix Gomez even converted the decisive penalty throw for the 28:27 winning goal at the end of regulation time and was obviously up to the pressure of the situation. Over the total playing time, Gomez achieved a PlayerScore value of 8.90 against Norway and thus the third-best value in his team. In this preliminary round match, too, his playing time was only 32 minutes.

In the Spain vs. Sweden match, Aleix Gomez put the score up to 32:30 in the 55th minute of the match through a 7-metre penalty throw and remained true and successful from the 7-metre mark. He played 59 minutes on the court in this match and a PlayerScore value of 27.24 meant the best value of his team in this preliminary round match.

Against Denmark and Egypt, no actions were observed and recorded by Gomez in crunch time!

Aleix Gomez achieved the second-best PlayerScore value (129.48) of all 185 players recorded in the tournament. He played 304 minutes in the 8 possible games. Even without the 7-metre penalty throws he converted, he would have been the best player of the tournament at the right wing position (81.33 PlayerScore points) ahead of the German Timo Kastening (64.41 PlayerScore points from 6 games) and the Frenchman Valentin Porte (50.15 PlayerScore points from 8 games).

Aleix Gomez was indispensable for the level shown by the Spanish team! It is very special for the Spanish team that in 3rd position in terms of PlayerScore points, a left-handed player appears again - Alex Dujshebaev (55.96 PlayerScore points). In second position is Adrian Figuera with (67.02 PlayerScore points) which strengthens the current importance of the circle player position based on objective data analysis!

Mikkel Hansen (LB)

In Denmark's match against Egypt, Hansen came on as an extra field player for Niklas Landin in the 55th minute of the match and promptly scored the goal to make it 29:26 for Denmark. Mathias Gidsel then switched with Landin to get the goalkeeper back on the pitch. The game developed positively for Denmark, so that Mikkel Hansen's converted 7-metre penalty throw made it 31:26 at 58:03 minutes. Hansen was the second most valuable player against Norway after his compatriot Gidsel with a PlayerScore of 20.08. His short playing time of 22 minutes is due to the fact that he was a specialist substitute or a 7th outfielder.

In the Denmark vs. Spain match, Mikkel Hansen converted a 7-metre penalty throw at 55:43 minutes of play to make it 24:22. He also scored the final goal to make it 27:23 after 59:44 minutes of play. Over the total playing time, Hansen's 35.05 PlayerScore points show him well ahead of the second best Dane on the day - Mathias Gidsel, who scored 19.36 PlayerScore points. In this preliminary round match Mikkel Hansen was on the field for 46 minutes.

In the final Denmark vs. France, Mikkel Hansen forfeits at the score of 22:24 after 57:57 minutes of play and does not play a decisive role in the final after the time-out at 58:06 minutes of play. Over the total playing time, Hansen achieved a PlayerScore value of 9.49 during 48 minutes of action. Breaking into the phalanx between the best scores of Mathias Gidsel and Mikkel Hansen at the final was the circle player Magnus Saugstrup, so Hansen proved his value to the team for the final in 3rd place behind Gidsel and Saugstrup.

Mikkel Hansen was not only the top scorer of the tournament, but also the third ranked player by PlayerScore for the complete tournament. In the 8 games in which Hansen was on the court for a total of 307 minutes, he achieved a PlayerScore value of 113.42. However, if you leave out the converted 7-metre penalty throws, Mikkel Hansen "only" achieved 16th place in the PlayerScore ranking (46.85). The Egyptians Ahmed Mohamed (66.60 PlayerScore points from 8 games) and Ali Mohamed (60.73 PlayerScore points from 7 games) and the Swede Jonathan Carlsbogard (62.80 PlayerScore points from 6 games) also performed exceptionally well in his position at left back.

Mathias Gidsel (RR)

In the Denmark vs Egypt match, Mathias Gisel increased the score to 30:26 with 57:00 minutes played. He also took a 7-metre penalty throw at the score of 30:26 after 57:56 minutes of play, which Mikkel Hansen also converted after 58:03 minutes of play to make it 31:26. Finally, Gidsel blocked the Egyptian throw on the empty Danish goal after 59:25 minutes of play, as Saugstrup had been substituted for Landin in attack shortly before. Over the total playing time, Mathias Gidsel achieved a PlayerScore value of 39.72 against Norway and was thus the most valuable player of his team in this preliminary round match. As already mentioned with Mikkel Hansen, Mathias Gidsel also got time on the substitutes' bench, so that he was on the pitch against Egypt for a total of 38 minutes.

In the Denmark vs. Spain match, Mathias Gidsel was awarded a 7-metre penalty throw at the score of 23:22 after 55:43 minutes of play, which Mikkel Hansen also converted for the 24:22 intermediate score (see above). Over the total playing time, the ranking turns in comparison to Mikkel Hansen (see above). Mathias Gidsel achieved 19.36 PlayerScore points during his playing time of 30 minutes and Mikkel Hansen takes the top place in his team in this preliminary round match with 35.05 PlayerScore points.

In the Denmark vs France game, Mathias Gidsel ties the game at 22-23 with 55:27 minutes played. He was not able to set more positive actions in the final phase of the final, on the contrary. At the score of 23:24 after 59:48 minutes of play, he loses the ball to Ludovic Fabregas, who is able to score the last goal for the final score of 23:25 as an empty-net-goal. In defence, he was regularly taken out for the goalkeeper's change back. This meant that he played a total of 35 minutes in the final. Over the total playing time, however, Mathias Gidsel achieved the best value for his team in the final with 13.60 PlayerScore points, followed by Magnus Saugstrup (13.14 PlayerScore points) and Mikkel Hansen (9.49 PlayerScore points). This value is the lowest sum value of PlayerScore points in the comparison of the three games considered.

All in all, Mathias Gidsel outperformed all other (field) players at the 2021 Olympic tournament and was unanimously named MVP by the IHF. Proof of this are 167.84 PlayerScore points, which he was able to collect without 7-metre penalty throws with his positive performances in 8 games.

Not surprisingly, after the analysis made, Mathias Gidsel (167.84 PlayerScore points) and Mikkel Hansen (113.42 PlayerScore points) were of special value to the Danish team. The next-placed players Jacob Holm (36.10 PlayerScore points), Johan Hansen (35.67 PlayerScore points) and Magnus Saugstrup (26.73 PlayerScore points) follow at a huge distance.

Ludovic Fabregas (P)

In the France-Germany match, Ludovic Fabregas misses a shot in the 57th minute of the match when leading 28:27. At 29:28, with 58:35 to play, he is awarded a 7-metre penalty throw, which his compatriot Hugo Descat is able to convert for 30:28 (see above). Overall, Fabregas does not occupy a top position in the ranking of his team in this preliminary round match (2.55 PlayerScore points). In a thoroughly balanced team, characterised by predominantly harmoniously distributed performance, Hugo Descat (15.77 PlayerScore points) and Kentin Mahe (14.48 PlayerScore points) led the way in the clash against Germany.

In France's tight preliminary round match against Norway, the scouts on site noted only 9 actions at all in the 5-minute crunch time, of which 5 were goal notes alone, namely from 29:27 to France's 32:29 victory. Fabregas obviously did not play a decisive role in the final phase of the match! Furthermore, what was said above about the Germany game applies. Fabregas scored 2.07 PlayerScore points in the game, again well behind Hugo Descat (14.64 PlayerScore points) as well as Luc Abalo (11.26 PlayerScore points).

In the final between France and Denmark, Ludovic Fabregas made the victory perfect by playing the ball out of the hands of Denmark's Mathias Gidsel at the score of 24:23 after 59:48 minutes of play and then throwing it into the empty-net goal for the final score of 25:23. This situation naturally earned him positive points, in total (7.27 PlayerScore points). In the end, "only" Nedim Remili (13.45 PlayerScore points), Luka Karabatic (12.52 PlayerScore points) and Romain Lagarde (9.60 PlayerScore points) rank ahead of the Olympic champion's circle player in the team-internal ranking on PlayerScore basis for the final.

France's Ludovic Fabregas achieved the best PlayerScore value for circle players in the tournament. Overall, this meant the seventh-best PlayerScore value (68.92) for him, with 335 minutes played in the 8 games. In his position, Spain's Adrian Figueras (67.02 PlayerScore points from 8 games) and Germany's Johannes Golla (41.39 PlayerScore points from 6 games) were the most competitive. If the 7-metre penalty throws of his team-mates and opponents are not taken into account, Fabregas' value even increases to such an extent that he achieves the fourth-best PlayerScore value of the 185 players used in the course of the tournament, which is now typical for the assist-giving style of play of the circle players. Ludovic Fabregas only has to give way to Mathias Gidsel (right back of Denmark), Nedim Remili (centre back of France) and Aleix Gomez (right wing of Spain). For France, Ludovic Fabregas proved his worth consistently behind Nedim Remili and Hugo Descat in particular.

Conclusion

The following questions were answered in the crunchtime analysis of the 2021 Olympic Games on a PlayerScore basis. 1:

1. how many goals were scored in the entire tournament and how many goals were scored in crunch time?

2. how many goals per minute on average were scored in the entire tournament and how many goals per minute in crunchtime?

3. how many goals per minute did a specially selected team (from the identified 15 close games) score/take in the overall tournament and how many goals did this selected team score/take in crunchtime?

4. which players have any actions at all in crunchtime and which players have repeated actions in crunchtime?

5. which actions are observed in crunchtime (at all)?

6. how did the above players rank in their own team over the course of the tournament?

The two hypotheses set up can also be confirmed! The IHF officials made a good choice in nominating the MVP and the AllStar team. The decision can also be understood very well on the basis of objective data!

As a follow-up to the presented data-based PlayerScore analysis, the authors want to carry out a systematic game observation of the 9 close games of the medallists considered in more detail here, as the emergence of game situations is denied by the underlying data basis. It will be interesting to see, among other things, how a team acts after a time-out. In all 38 games during the Olympic Games, a team time-out was taken 32 times in the last 5 minutes. It sounds plausible that in the 15 close games this tactical coaching option was used 18 times and in the 9 close games of the medal winners 11 times, whereby in four matches both teams had the game interrupted for one minute in the last 5 minutes.

Keywords

Olympic handball tournament, Tokio 2021, PlayerScore, close games at crunch time, quantitative data analysis

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PERCEPTIONS OF FEMALE HANDBALL PLAYERS ABOUT THE TRAINING PROCESS DURING COVID-19

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Summary

The aim of this study is to capture the perception of the handball players of a Portuguese first division club regarding the physical preparation carried out in the field and at home during the COVID-19 pandemic. Nineteen female experienced players were interviewed. The players understood the importance of physical conditioning and the need to continue training during the isolation period, but the absence of daily social interaction, and the distance from the court environment demotivated them.

Key-Words: HANDBALL TRAINING, STRENGHT AND CONDITIONING, COVID-19, PERCEPTION, PSYCHOLOGY

Introduction

The emergence of the new ß-coronavirus, in November 2019 in China, quickly spread throughout the world and brought unprecedented challenges and complications to every human activity (Lauxmann, Santucci, & Autrán-Gómez, 2020; WHO, 2020; Yi et al., 2020). Faced with this situation, different policies and rules were established in each country with the purpose to contain the spread of the disease (Askitas, Tatsiramos, & Verheyden, 2020). One common strategy and recommendation was the quarantine and social isolation (CDC, 2021; Davies et al., 2020; Hwang et al., 2020), forcing the population to stay at home and adapt their regular routine.

Accordingly, athletes and coaches had to adapt their training sessions (Jukic et al., 2020), addressing the maintenance of the physical condition (Eirale et al., 2020; Herrera-Valenzuela, Valdés-Badilla, & Franchini, 2020). In Portugal, on 12 March 2020, the Portuguese Handball Federation decided to suspend the training on the field/court and the championship, with the possibility of resumption on 29 March 2020 (FAP, 2020). In this scenario, coaches kept the training sessions in a home-based environment, following WHO and FAP (2020) recommendations to avoid COVID-19 infection. However, with the evolution of the pandemic and the several renovations of "emergency state" from the government of Portugal which maintained the population for seven consecutive weeks with movement limitations, FAP decided to close the championship without a winner on 29 April the same year (FAP, 2020).

As it is known, social isolation and loneliness can lead to psychological disorders, mental illness, emotional disturbs and physical health consequences (Füzéki, Groneberg, &

Banzer, 2020; Hwang et al., 2020; Loades et al., 2020; Ribeiro, 2020; Schinke et al., 2020). Also, periods like this home-based training, where a load of training session is inevitable different than the usual applied during a normal season, such as rehabilitation or off-season months, can lead to several detraining levels, with loss in the cardiorespiratory capacity, muscle mass and strength, flexibility, neuromuscular control, and other aspects of athletes performance (Eirale et al., 2020; Mujika & Padilla, 2000a, 2000b; Sarto et al., 2020). Thus, one of the great needs of the training process of these athletes became the mitigation of the potential effects of confinement, which could lead to detraining and deconditioning of the sports form, in several dimensions.

A lack of knowledge exists about how handball players experienced the training process during the pandemic times. Thus, the main purpose of this study was to capture the perception of the handball players of a Portuguese first division club applying for the national title regarding the physical preparation carried out on the field during the regular competitive season and at home during the beginning of COVID-19 pandemic.

Methods

Nineteen female experienced players from a team competing in the first Portuguese handball league participated in this study. The average of height, weight and age were 166.9 cm (±6.1), 67.1 Kg (±6.0) and 23.3 years old (±4.4) respectively and aged between 20 and 34 years old. The players had been playing handball for an average of 14.3 (±4.0) years and had represented the present club for 7.5 (±5.2) years. After the suspension of indoor training sessions, eight weeks of on-line training were planned with five sessions per week, and a duration between 40 to 90 minutes. The trainings were based at High Intensity Intermittent Training (HIIT) (Laursen & Buchheit, 2019) and Complex Training (CT) (Carter & Greenwood, 2014) methodologies and were focused on the maintenance of the strength and conditioning levels of the players, because of the possibility of resuming the championship. Players were instructed to perform the sessions at home or in an outdoor place nearby their house, recording it with the "time-lapse" function of a smartphone.

For data collection on-line individual semi-structured interviews were conducted from April to July 2020. The script was prepared based on the research objectives and analyzed by two experts in the field of Sports Science, to verify the adequacy and understandability of the questions to the content validation. A pilot interview was also carried out to verify if the questions were clear and if the answers corresponded to the study's objectives. The pilot interview was carried out with a former player from the team under study, but who was at the time playing for a foreign team, thus possessing knowledge about the Portuguese reality and the club in question. The final version of the interview was established, with 10 questions concerning: (i) physical requirements of handball practice in general; (ii) requirements for specific and individual playing positions; (iii) physical demands of international competitions; (iv) the opinion on the measures for injuries prevention and the physical preparation performed during the season; (v) the commitment and availability of the players to train; (vi) the experience of training at home during mandatory isolation; (vii) the advantages and disadvantages of training at home and on the field together with teammates; (viii) what the players most valued in the teamwork; (ix) what is their own assessment of their performance

level at the end of the season to return to competition; and (x) what the prospects for the future are.

The information from the interviews was analyzed using the assumptions of content analysis (Bardin, 2011), crossing inductive and deductive procedures. The categories identified were: (I) challenges and constraints of training at home, (II) advantages and achievements in training at home, (III) elements valued in teamwork, (IV) current performance level, and (V) return to sports practice after isolation. The NVivo 12 software was used for coding, organizing, and analyzing the collected data. All the participants signed an informed consent, and the data were codified to maintain the anonymity.

Results and Discussions

Almost all the players considered physical preparation and injury prevention measures fundamental dimensions of training. In social isolation, the lack of motivation to practice at home was evident, due to the lack of physical social interaction and adequate training materials, as well as the closing of the competition and the overload of academic and working life.

Regarding the experience of training during the COVID season, the players talked about challenges and constraints, advantages, and overcomes in training at home, elements valued in teamwork, current performance level, and the return to sports practice after isolation (see Table 1). According to the relevance of the data and the aim of this study, this paper will only explore the two main categories: "challenges and constraints of training at home" and "advantages and achievements in training at home".

Table 1. Categories: challenges and constraints of training at home, advantages and overcomes in training at home, elements valued in teamwork, current performance, return to sports practice after isolation – sub-categories and references (nº and %)

Categories	Sub-categories	References/Mentions	
		Total	**Percentage**
Challenges and constraints of training at home	Nutrition	3	16%
	Environment	**12**	**63%**
	Championship (the closing)	9	47%
	Lack of physical social interaction	**15**	**79%**
	Space to practice	9	47%
	Exercises and methodologies utilized	**14**	**74%**
	Time management	**12**	**63%**
	Long period of social distancing	4	21%
	Equipment available to training at-home	**15**	**79%**
	Fear of COVID-19	3	16%
	Lack of motivation	**17**	**89%**
	Lack of goals	8	42%
	Personal problems	2	11%
	Difficulty in the technical execution of the exercise	9	47%

	Academic life, work, and personal life.	**12**	**63%**
Advantages and achievements in training at home	Adaptability	**10**	**53%**
	Training knowledge	2	11%
	Autonomy to train	5	26%
	Presence of a friend or family member to train	**9**	**47%**
	Maintaining fitness	7	37%
	Schedule management and planning	6	32%
	Investment in training materials	3	16%
	Greater volume and intensity of physical training	5	26%
	New experiences	5	26%
	Increased possibilities for training and creativity	5	26%
	Increased responsibility	6	32%
	Personal achievements	5	26%
Elements valued in teamwork	Fellowship (support and help)	**15**	**79%**
	Competitiveness	7	37%
	Communication	7	37%
	Fun	5	26%
	Socialization	8	42%
	Resilience	8	42%
	Unity for a purpose	**13**	**68%**
Current performance	Positive	3	16%
	Negative	**17**	**89%**
Return to post-isolation sports practice	There will be repercussions	**15**	**79%**
	There will be no repercussions	8	42%
	Motivation	5	26%

Challenges and constraints

The main constraint during training at home was the lack of motivation (89%). Following this constraint, the lack of physical social interaction and material available for training was mentioned by 79% of the players. The exercises and methodologies applied (75%), personal, academic, and professional life (63%) and the difficulty in managing and planning timetables (63%), as well as the environment in which they found themselves (63%) were also referred to.

> *Player 06: "Horrible!* ***(…), there is no motivation****.* ***I mean, there was, until a time when we expected to go back to competing****. A person didn't want to be coming back and being there a month again in pre-season because we were physically weak. (...). Then, when it was really decided that there would be no*

more games and the championship was over, and, on top of that, they decided that we weren't going to be champions [at the time, they had first place in the competition], I think it all hit very hard, maybe, not just for me, but for all of them (...)"

*Player 01: "It's horrible. It's horrible! (...). First, the teachers sent a load of homework, and then**, I couldn't juggle the time very well**. (...). Not so much doing nothing, but it wasn't at the same intensity as it had been in on-court training. It wasn't the same rhythm either, it wasn't the same tempo. (...) Because the university demands exceeded the importance of sports. Because it's true and I won't lie, college will give me something that handball will never give me. And so, I had to have priorities**. So, my priority was the university**."*

Player 09: "It's not that the planning [at-home training] was wrong, not that the planning didn't try to meet our needs, but because of individual reasons (...) ***It's a lack of motivation, a lack of people, even to motivate each other, because that's what naturally makes a group****."*

After the decision to closing the championship without a winner, most of the players didn't have any **motivation** to keep training at home. Also, this decision was taken during the fourth week of the online training, and the attendance at the training drastically fell after that, showing how much players were directly influenced by the competition and practiced with this purpose (Table 2). In addition, physical training aims to contribute to reducing the risk of sports injuries, better preparing the players to overcome the opponent (Sommi et al., 2018; Stojanovic & Ostojic, 2012), and without the presence of the adversary, this main purpose of the conditioning is lost. This is in line with the findings of Schinke et al. (2020a) who found that moments of crisis or immediate termination of activity submits athletes and coaches to psychologically and emotionally challenging situations.

Table 2. Number of players present during the on-line training session.

WEEK	SESSION OF THE WEEK					AVERAGE ATTENDANCE
	1st	2nd	3rd	4th	5th	
	NUMBER OF PLAYERS AT THE SESSION					
1	15	15	15	15	12	**14**
2	15	15	11	12	14	**13**
3	14	13	9	7	3	**9**
4	9	8	6	7	3	**7**
5	7	5	5	4	3	**5**
6	5	2	2	2	2	**3**
7	6	2	1	-	1	**3**
8	3	2	2	1	1	**2**

According to Simões, Moreira, and Pellegrinotti (2017), "playing is a motivating factor, it is to experience pleasure in carrying out the possibilities of performing the tasks, it is to improve fundamentals in an intense and contextualized way, taking us above the capabilities already developed." (p.69).

Elite and sub-elite South African athletes reported feeling depressed and needing more motivation to stay active during the lockdown (Pillay et al., 2020). On the other hand, it is known that athletes in a team sport train with the objective of developing and improving their skills and competences to be better prepared than their opponents at the time of testing or evidence within a competition or dispute in common (Kent, 2016). From the moment that national and international competitions were canceled or postponed, the participation and motivation of the athletes towards the trainings drastically reduced, reaching, in some cases, “completely disappearing”, as referred by most athletes.

Another relevant sub-category was the **absence lack of social** interaction. Athletes from team sports tend to have lower levels of perseverance, resilience, and self-efficacy, when compared with athletes from individual sports, who have more responsibility because of their individual performance (Laborde, Guillén, & Mosley, 2016). However, active individuals who used to practice with partners also decreased their levels of physical activity during periods of lockdown (Constandt et al., 2020). One explanation could be that the most valued element of the training reported by the players, the fellowship, also known as team spirit and group experiences, were what they missed the most when far from the sport context (Ekengren et al., 2020). Also, the absence of the social aspect present in team sports, like the teammates in the day-to-day of training, negatively affected the players (Costa et al., 2020). Taku and Arai (2020) observed that Japanese Olympic and Paralympic athletes had increased levels of anxiety and uncertainty due to limited interaction with teammates, coaches, and other individuals. In addition, this home program was sent to the players, and they could choose the day and time of preference during the week to execute it, without the presence of the coach or investigator during the session, which contributed to lower adherence and lower social interaction (Burke et al., 2005).

Another important constraint was the **lack of adequate equipment**. The condition of materials and the absence of another person to exercise were important obstacles faced during quarantine (Goethals et al., 2020). In addition, changes in training conditions through social isolation with less equipment and smaller space to exercise directly contributed to presence of depressive symptoms (Amerio et al., 2020), and the reduction of training levels (Amatriain-Fernández et al., 2020), such as intensity and volume (Mon-López et al., 2020). If players had an environment with availability of cardiovascular and strength training materials, greater achievement, planning, intention, autonomous motivation, and habits for the practice of physical exercise could have happened (Kaushal et al., 2020).

Most of the participants in this study reported having difficulties in training at home because the home is an environment in which they normally relax, rest, unwind, and, therefore, do not have the psychological burden associated with training, such as intense and regular physical effort, of physical resilience. Following the principle of training adaptation, several and different loses can be expected in the players’ performance and capabilities after short and long periods due to the reduction of the training stimulus (Mujika & Padilla, 2000a, 2000b).

Different athletes from varied countries and sports reported similar losses like the constraints above (Gupta & McCarthy, 2021). Gathering the constrains reported, the climate of uncertainty in the sport context, about the resumption of competition, changing in the regular training routine, no access to sports facilities and coexistence with teammates, in addition to the new rules for conducting competitions, are potentiating factors for the degradation of the psychological state of players (di Fronso et al., 2020).

Advantages and achievements

Regarding this category, the most transversal mention was the adaptability (53%), followed by the company of a friend or family member to train (47%).

> Player 12: *"Man, I'm not going to say it's a bad experience, because there it is,* ***I think that all experiences end up having their positive point in relation to things****. I think maybe it was to give a little more value to our training on the court and, maybe, to give a little more value to the work we did before. (...) In other words,* ***we had to adapt, make several adaptations, the weights****, maybe, were kilos of rice, or detergents to adapt. And that also turns out to be a good thing."*
>
> Player 14: *"But yes, speaking in my case (training with my boyfriend), it made all the difference. Yes, (...) you are not understanding. Look... I'm an animal!* ***And I liked [the at-home training] very much****. (...) Like, we always practice, we always find a way to do some training. (...).* ***We're setting up a home gym right now****. I've already canceled my gym contract (laughs). Because* ***I'll always start training at home like this****. Yes, but I liked it a lot. (...).* ***I think I worked on things I never had time to work on before****."*

Many are the recommendations to avoid the loneliness and psychological disorders from the social isolation, being the communication between peers one of them (Williams et al., 2021). Most of the players trained alone, like findings of Pillay et al. (2020), but some could practice with family or friends, which contributed to increase the motivation and commitment with the training sessions, with better experiences during the at-home-based training.

This capability to adapt materials and overcome new adversities in the training routine is also part of the athletes' resilience, which contributes to the maintenance of the players' well-being (Martínez-González et al., 2021). Also, depending on the type of the exercise, for example, the HIIT methodology, the level of resilience can be increased even more (Borrega-Mouquinho et al., 2021).

The development and stimulation of resilience is an important subject that should be present in the daily training, especially with young female athletes who faces numerous challenges beyond the opposite team on the court, such as gender inequality and body discrimination (McManama O'Brien et al., 2021).

Conclusion

The experience of being isolated and confined for a long term in a home-based environment and continuing to exercise to maintain the physical condition was a major obstacle for most players. The lack of motivation, social interaction, and adequate equipment to practice on were the biggest challenges reported by them. The sudden closure of the championship, the absence of the daily interaction, and the distance from the court environment were the main elements that led to the players' difficulty in keeping training at home. Nevertheless, there were positive reports about the adaptability and resilience experienced during this period. To practice with relatives or a friend and the adaptation of equipment and routines were highlighted by the players.

The players' understood the importance of physical conditioning and the need to continue training during the isolation period but it was tough for them to overcome this new situation. With this, a high detraining effect could be projected after confinement. Some recommendations that could help in similar situations in the future is that players previously acquire some basic equipment or create it with similar objects at home. To the clubs and coaches, we suggest online sessions with the presence of all players or in small groups and with the leadership of a coach. We add the importance of a psychological follow-up of the team and the creation of virtual spaces where players can share their experiences with each other and with the team official professionals in the club.

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FURTHER TOPICS PRESENTED AT THE SCIENTIFIC CONFERENCE

CAN IMUs BE USED TO DETECT DIFFERENT THROWS AND ESTIMATE BALL VELOCITY IN TEAM HANDBALL BY MACHINE LEARNING?

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Injuries in handball are common due to the repetitive demands of overhead throws and their variety at high velocities. One of the major risk factors for elbow and shoulder injuries is training load (undertraining and overtraining). Monitoring training load is crucial for understanding these demands and improving injury-prevention strategies. However, in handball, it is challenging to monitor throwing load due to the difficulty of counting the number, intensity, and type of throws during training and competition.
The aim of this study was to investigate if an inertial measurement unit (IMU) and machine learning (ML) techniques could be used to detect different types of team handball throws and predict ball velocity. Seventeen players (10 men and 7 women, age 28.0±7.3 years, body mass 74.4±13.6 kg, body height 1.77±0.09 m, handball training experience 17.7±9.6 years) performed several throws with different wind-up (circular and whip-like) and approach types (standing, running, and jumping) while wearing an IMU on their wrist. Ball velocity was measured using a radar gun. Four different supervised machine learning models were used to classify throw type (circular or whip-like) and throw approach type (running, standing, or jumping) from the signal features and to estimate ball velocity, as measured by the radar gun. ML models predicted peak ball velocity with an error of 1.10 m/s and classified approach type and throw type with 80–87% accuracy. Using IMUs and ML models may offer a practical and automated method for quantifying throw counts and classifying the throw and approach types adopted by handball players.

COMPARISON OF SHOULDER KINEMATICS AND MUSCLE ACTIVATION OF FEMALE ELITE HANDBALL PLAYERS WITH AND WITHOUT PAIN

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This study investigated the kinematics and muscle activation during throwing in female elite handball players with and without shoulder pain. 30 female elite team handball players, 15 with pain (Age 22.2±2.9, height 1.76±0.07m, weight 73.8±9.7) and 15 players without pain (Age 20.4±2.6, height 1.72±0.05m, weight 66.9±3.9) performed five standing throws during which 3D joint kinematics and muscle activity of seven muscles was measured. The main findings were that maximal joint angles and angular velocities were not different between the groups. The only differences between the groups were observed in earlier time of occurrence of the maximal shoulder extension and external shoulder rotation in the pain group compared with the no pain group. Of the muscles only the serratus anterior showed, during the cocking phase higher peak activity in the no pain group compared with the pain group, which decreased to a lower peak activity at ball release, while the pain group had similar peak EMG activity during all three events. This higher activation was probably caused by the higher shoulder extension velocity to move the ball up and backwards (cocking phase) in the no pain group. It was concluded that absence of major differences in kinematics is probably due to the variance of throwing between athletes. The earlier occurrence of the maximal shoulder extension could be a mechanism and adaptation to avoid pain to decrease the peak acceleration of the arm. The transfer from the cocking to the ball acceleration phase is performed during a longer time period, which potentially may reduce the peak load during ball acceleration.

E-HANDBALL NEXT STEPS

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Handball continues to grow all around Europe. Even with the pandemic the different numbers are very positive and create good expectations. 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 its variants (Indoor, Youth, Mini-handball, Beach Handball, Wheelchair Handball, …). Handball also needs a continuous increase in the number of fans and new players. Grassroots plays an important role to guarantee a sustainable growth of Handball. Young people have today a huge offer of activities. Sport is only one of this several offers. And inside sport also Handball is only one of several sport offers.

Technology, specially gaming and esports, entered in our society with huge impact in the last 20 years. Today we truly believe that gaming has no turning point, it will continuously increase throughout the years. And the youngsters that we want to bring to Handball (or that they stay!) will always be attracted by gaming and esports.

We think gaming and esports should be approached in three steps: in the first step the handball community should have access to information about what is gaming/esports, its impact in our society, threats, and opportunities. Coaches, Team Managers, Parents should be the target groups, and present them method case approaches. In a second step technology, together with gaming and esports, are an education utility we will use in the future, they will improve players and coaches' decisions. The last step should be the use of technology, gaming and esports connected with handball throughout the handball community. This will lead to physical handball specific, mixed-reality sports, and a VR esports that is more dynamic.

Keywords: Handball, esports, gaming, education, technology

MAIN OBSTACLES IN THE SPORT PRACTICE OF YOUNG PEOPLE WITH A MIGRANT BACKGROUND AND THE SOCIAL FACTOR AS A VALID APPROACH

Carlos Prieto. Athletes Inspire Children NGO. Wetzlar, Germany. 2021

The migratory movements that have taken place in recent years are showing us a reality that has a direct link with sport and that affects its practitioners. In Germany, it has been found that young people are more likely to drop out of sport if they have a migrant background. Furthermore, the most affected young people are teenage girls. The language barrier and the socio-economic situation are two of the main factors that have the greatest impact on this fact. Membership in clubs and/or associations has also been identified as a decisive factor for continuing to practice organised sport. The space to practice sport and the opportunity to be part of a community seem to solve part of the problem pointed out by the two factors mentioned above. These data show the importance of the role that both clubs and/or associations and coaches play in meeting the needs of young people and therefore the relevant part they play in society as elements of social inclusion.

REBUILDING A TEAM AFTER A YEAR OFF - A SMALL NATION APPROACH.

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Ireland is currently ranked in the third tier of European Olympic Handball nations. Throughout the Covid-19 pandemic handball in Ireland suffered, with strict restrictions on indoor sports causing massive disruption to training and the competitive season. After the initial lockdown and restrictions were eased, the Irish Olympic Handball Association began the task of a safe return to sports. This return began outdoors over the summer period of 2021, during the off season and without a set return for indoor sports. This led to issues with training schedules, player and coach availability, and fitness. A large degree of flexibility and adaptability to training conditions was required for the first few months from both coaches and players.
We hypothesize that comprehensive fitness testing and increased support for our returning players significantly helped our safe return. Collaboration between Astra Handball Club and UCD's Institute of Sport and Health greatly supported this return by collaborating on fitness testing, monitoring, and the development of an injury prevention program for the athletes. Prior to the return of outdoor training, online one-to-one strength and conditioning coaching was made available to players returning from injuries to facilitate their return to play. Testing during the first training sessions showed that while there was a large variance, on average the returning players had a higher level of overall fitness compared to the general population. Post testing, these results were used to develop strategies that would support the players return to high activity levels while using injury prevention programming and a slow build-up of intensity over the entire summer period. The enhanced support in place within the team will continue to support the transition into the competitive season.

Specific on-court performance in elite male adolescent team handball players

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Introduction: In elite team handball, talent identification and selection of the best young players is a fundamental process in several national federations and clubs; however, literature-addressing the specific on-court performance in team handball is almost nonexistent. Consequently, the aim of the study was to assess and compare the team handball specific on-court performance of elite male team handball players of different ages.

Methods: Twelve under-23, ten under-19, ten under-17 and ten under-15 elite male players performed the team handball game-based performance test. During testing, oxygen uptake, heart rate, sprinting time in defense, offense, fast breaks and fast retreats as well as ball velocity and jump height in the jump shot were measured.

Results and Discussion: Significant differences ($P<.05$) between under-23, under-19, under-17 and under-15 players were found for absolute peak oxygen uptake, defense, offense and fast break time, ball velocity and jump height in the game-based performance test as well as in body weight and height. In conclusion, our results revealed that with increasing age, elite male team handball players are heavier and taller (body weight and height), faster (team handball offense, defense, and fast break), jump higher and throw faster (in the team handball jump shot), and perform better aerobically (absolute VO_2peak). The better performance in the under-23 and under-19 players, compared to elite male adult players in a previous study demonstrates the necessity of highly specific on-court physical performance to become a top-elite team handball player.

STUDENTS' VOICES ABOUT TEACHING TOWARDS AN INCLUSIVE AND MEANINGFUL HANDBALL EXPERIENCE

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Despite the efforts of pedagogy and didactic courses to shift Physical Education (PE) towards a meaningful participation and learning, preservice teachers remain unprepared to solve problems of marginalization, exclusion and underachievement, namely in handball teaching, where the traditional technical and teacher-led practice is still prevailing, not giving place to innovative game-based approaches. The main purpose of this study is to capture the opinions of PE students about handball classes where PE preservice teachers tried to use inclusive and Game-Based Approaches considering the diversity of student characteristics, needs, and how they engage and learn during the process. This is a participatory action research study framed upon a scaffolding process involving a preservice teacher without experience in handball teaching/coaching, a PE teacher educator (specialist in specific didactics for handball) and a school PE cooperating teacher. The participants were 28 students from a private high school in the Greater Porto urban area, comprising a handball unit of 14 lessons. Key instructional strategies, modified game rules and action constraints were introduced and shaped during the lessons, attempting to trigger less skilled students' active participation and game play accessibility. Semi-structured interviews with selected students were conducted by the end of the unit about the extent to which all teammates were motivated and involved in the tasks and improved their game skills and play participation. Students mentioned liking the classes very much; they really enjoyed belonging to a team, cooperating and communicating with each other and considered that it helped them to overcome shyness. It was also reported that they improved relationships with colleagues that they hadn´t had much interaction with. Some of them also emphasized that had learned not only about handball, improved their technical skills and tactical actions, but had helped others because they had helped them too.

TEAM HANDBALL AND THE EMPTY GOAL (*7 VS 6*) RULE – THE COACHES´ PERCEPTION

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The introduction of changes or new rules in Handball has been a constant in the last two decades. This aspect arises to make the game faster, spectacular and increasing intensity.

However, few rules were as controversial and not consensual as the rule that allows the change of a goalkeeper for a field player (Empty goal) allowing teams to play 7 vs 6. This rule has been contested and caused some division between the coaches' opinions, despite being an increasingly frequent practice.

With this study we intend to evaluate the perception of coaches from several countries about the rule that allows them to play 7 vs 6 without goalkeeper.

The sample included 125 coaches from different continents such as European, South American, African and Asian. For data collection, a previously constructed and validated questionnaire was used and applied with Google Forms (125 questionnaires were used).

The results show that: a) 76% of the coaches agree with the possibility of playing 7 vs 6; b) 41% indicates that the game was uncharacterized; c) 40.8% say that the introduction of 7 vs 6 is a natural evolution of the game; d) 33.9% is in favor of the exclusion of the rule that allows teams to play 7 vs 6.

Further studies are needed to understand what changes this rule caused in the game and in the behavior of teams, players and coaches, and verify if a major acceptance of this rule occurred and if it is more used by coaches.

Keywords: Handball, 7 vs 6, Empty Goal ,Coaches, Perception.

THE VALIDITY AND RELIABILITY OF ON-SAND JUMPING PERFORMANCE USING MOBILE DEVICES

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Sports that are performed on sand such as handball are characterised by many physical components, one which is often observed as a key component is ones jumping ability. Vertical jumping capability helps classify performance level and can be used as a tool for the evaluation of training intervention. Although jumping has been often measured using a variety of devices, due to practicality and feasibility, this has often been conducted on firm ground and assumed applicable and representative to that of sand. Sand surface poses its own additional difficulties as the unstable surface needs to be controlled for and in-field implementation by use of gold-standard measures such as force plates is difficult. As such, the application of ecologically valid and in-field measurements of jumping performance are important to more accurately describe and classify high-level performance and to accurately inform practitioners of their athletes' capacities and responses. Therefore, the aim of the current study is to validate MyJump2 (an app-based measurement tool) and VERT® on sand surface to explore options of in-field measurements on sand.

A total of 21 subjects performed five consecutive countermovement jumps (CMJ) in a sand box placed on force platforms on two measurement time points. CMJ heights were recorded by three measuring devices; force plates (criterion measure), MyJump2 app and VERT®. To validate the devices heights, based on flight times, were compared to the criterion device using intraclass coefficient (ICC; both, absolute agreement and consistency) and Pearson's r correlation coefficient.

Correlation between MyJump2 app and force plates can be classed as 'good' to 'excellent' ($ICC_{absoluteagreement}$ = .86; $ICC_{consistency}$ = .97; r = .97) with a mean difference of -3.31 cm (range, 14.56 to 45.00 cm). ICC ($ICC_{absoluteagreement}$ = .55; $ICC_{consistency}$ = .86; r = .86) of VERT® and force plate indicates a 'moderate' to 'good' correlation with a mean difference of 6.25cm (range, 22.40 to 63.10 cm).

The results of the present study indicate that CMJ height can be easily, accurately and reliably evaluated in an ecologically valid setting using an app-based assessment tool, MyJump2. However, the use of VERT® does not appear to be a useful method to measure jumping performance on sand. Although, the ICC and correlation coefficients do not appear "too poor", the unsystematic direction of jumping height, alongside mean differences of over 5 cm does not lend itself elite level sporting practice. Nevertheless, the results do suggest that there is a method that coaches and practitioners can collect a greater berth of information to classify and inform the training process in settings that are representative to the true demands of the sport, rather than depending on potentially non-transferrable information.

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