UNIVERSIDADE D
COIMBRA

Tiago Emanuel da Costa e Sousa

THE RINK HOCKEY GOALKEEPER:

SOMATIC CHARACTERISTICS AND ACTIVITY PROFILE.

Thesis for the degree of Doctor in Sport Sciences in the branch of Sports Training supervised by Prof. Dr. Vasco Vaz and Prof. Dr. Hugo Sarmento, submitted to the Faculty of Sport Sciences and Physical Education of the University of Coimbra

September of 2021

Faculty of Sports Science and Physical Education
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“The truth is I can’t tell you how often I give the same answer to a different question.
People ask questions and I tell them to ***Keep It Simple****.*
Stay in the box.
Out-of-the-box thinking should be reserved for those who know the inside of the box like the literal back of their hand.”
Michael Boyle, 2014

To me, to my family, friends, Professors and to the game I love.

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Abstract

This Thesis aims to contribute to the development of empirical and theoretical knowledge of the rink hockey goalkeeper as well as to understand the demands associated with rink hockey performance.

The first chapter comprises a general introduction, the theoretical framework that led to the realization of this study as well as the objectives and structure of this Thesis.

In the second chapter, we systematically reviewed and organised the available literature on match analysis in rink hockey accordingly to PRISMA guidelines. The results of this review highlighted that rink hockey could be characterised as a sport where half of the offensive actions end with a shot at goal, but only a small number of these shots end with a goal. Additionally, there are differences in technical demands between player position and reductions in movement intensity in the second half of matches.

In the third chapter, we included the second study of this Thesis where we developed and validated an observational instrument tool to analyse the activity of rink hockey goalkeepers. We also conducted a query, to coaches and goalkeepers, to create a nomenclature for the different techniques of rink hockey goalkeepers. The results suggest that “knee on the floor” and “squatting” are “basic position”, “spatula” and “side fall” are “emergency position” and that “fleck” could be considered as a “position of expectation”, as an “optimum position” and also as an “emergency position”.

The fourth chapter included a study through which we investigated the activity and performance of the rink hockey goalkeeper and assessed whether the oppositions attacking play has any relationship with goalkeeping performance. The results suggested that: rink hockey goalkeepers are more effective in the 1st halves of the matches; that their effectiveness is lower in direct free-hits and penalties; “knee on the floor” is the most common technique; when attacks start in the oppositions defensive area, teams are more likely to score a goal, and; shots at the upper zones of the goal have a higher probability of being successful.

The fifth chapter comprises a study through which we analysed and compared the anthropometric characteristics of male rink hockey goalkeepers according to their competitive level (international vs. non-international). The results of this study indicated us that international rink hockey goalkeepers have lower values of subcutaneous adiposity for the sum of the four skinfolds particularly in the triceps and medial calf. And also that, stature and body fat may have important implications for scouts regarding the selection process and coaches that work with players on developing performance.

The sixth chapter contains a study through which, the use of semi-structured interviews, sought to access the perceptions of rink hockey head coaches concerning the tasks of preparation/observation, intervention and adaptation of training exercises and also the bespoke position of rink hockey goalkeeper. In general rink hockey head coaches, prefer to perform the analysis of the opponents' teams to plan training sessions, as well as to assist with tactical preparation and implement within-match strategies. They consider video analysis an important tool to analyse the opponents' strengths and weaknesses, with particular focus on the opponents' goalkeeper. The most important game moments to analyse are the defensive and offensive organisation, the defensive and offensive transitions and set pieces. The training intervention involves the adaption of training exercises, whereby information is communicated during meetings. Coaches consider effectiveness, technical quality and a good positional sense important for the goalkeeper.

The last section comprises the seventh chapter in which the findings of the different studies are summarised and put into context and their implications discussed. Our work highlighted the characteristics and activity profile of the rink hockey goalkeeper and also the performance demands of the game. These data have implications for head coaches, performance analysts and goalkeeping coaches from both a performance and training practice perspective.

Keywords: roller hockey; match analysis; goalkeepers' techniques; body composition; coaches' perceptions.

Resumo

Esta tese visa contribuir para o desenvolvimento do conhecimento empírico e teórico, do guarda-redes de hóquei em patins, bem como compreender as variáveis associadas à *performance* no hóquei em patins.

Neste sentido, é apresentada nos dois primeiros capítulos, não só a introdução, mas, também, uma revisão sistemática da literatura, onde se sintetizam as evidências científicas disponíveis na literatura, no que concerne às exigências técnicas e táticas nesta modalidade desportiva e que servem de suporte aos objetivos traçados na presente tese.

No terceiro capítulo, procedemos ao desenvolvimento e validação de um instrumento de observação, para análise do desempenho dos guarda-redes de hóquei em patins. Além de se ter efetivado uma normalização da terminologia utilizada no que concerne às diferentes técnicas utilizadas, o instrumento revelou níveis adequados de fiabilidade intra e inter observador.

No quarto capítulo, investigámos a atividade e o desempenho do guarda-redes de hóquei em patins. Os resultados indicaram que: i) os guarda-redes de hóquei em patins eram mais eficazes nas primeiras partes dos jogos; ii) que a sua eficácia era inferior nos livres diretos e penáltis; que a técnica "joelho no chão" era a mais utilizada; iii) que, quando os ataques começavam na área defensiva do adversário, aumentava a probabilidade de marcar golo, e que; remates executados para as zonas superiores da baliza tinham maiores probabilidades de sucesso.

Posteriormente, comparámos as características antropométricas dos guarda-redes masculinos de hóquei em patins, de acordo com o seu nível competitivo (internacional vs. não internacional), onde se concluiu que os guarda-redes internacionais tinham menos adiposidade subcutânea no somatório das quatro pregas, particularmente, nas pregas tricipital e geminal. A estatura e a gordura corporal podem ter implicações práticas importantes no processo de seleção dos guarda-redes por parte de treinadores e observadores.

No último estudo, a partir de entrevistas semiestruturadas, procurámos aceder às perceções dos treinadores em relação às tarefas de preparação/observação (da própria equipa, bem como das equipas adversárias), intervenção e adaptação de exercícios de treino e, ainda, relativamente ao guarda-redes de hóquei em patins. Em traços gerais, verificou-se que os treinadores de hóquei em patins preferiam ser eles a realizar a análise das equipas adversárias para planearem treinos, bem como auxiliar na preparação tática e implementação de estratégias para o jogo. Consideram ainda que a análise de vídeo era uma ferramenta importante para analisar os pontos fortes e fracos do adversário, prestando particular atenção ao desempenho do guarda-redes adversário. Os momentos de jogo considerados mais importantes de analisar foram a organização defensiva e ofensiva, as transições defensivas e ofensivas, bem como as situações de bola parada. A intervenção no treino envolveu a adaptação de exercícios, sendo que a informação considerada mais importante, acerca do próximo adversário, foi comunicada durante reuniões de grupo. Os treinadores consideraram a eficácia, a qualidade técnica e o bom posicionamento na baliza como características importantes para o guarda-redes de hóquei em patins.

No último capítulo, as conclusões dos diferentes estudos foram resumidas e contextualizadas e as suas implicações discutidas. O nosso trabalho destacou as características e o perfil de atividade do guarda-redes, assim como as exigências de desempenho do jogo de hóquei em patins. Estes resultados têm implicações práticas para treinadores, analistas de desempenho e treinadores de guarda-redes, tanto na perspetiva da *performance*, como do treino.

Palavras-chave: hóquei em patins; análise de jogo; técnica de guarda-redes; composição corporal; perceção dos treinadores.

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SECTION I

CHAPTER ONE: General Introduction

1. Introduction

One of the most influential changes in sports development in the world today is, undoubtedly, the application of science to the problems of sport, that is, the use of an increasing perfectionist technology, supported by scientific data, that allows us to establish a code of reading and analysis of sports reality (Fernández, Varo, Carmona, & Reche, 2020; Fernández, Novelles, Tarragó, & Reche, 2020; Gama, Dias, Couceiro, Sousa, & Vaz, 2016; Pereira et al., 2017; Sarmento et al., 2016; Silva, Marcelino, Lacerda, & João, 2016).

In the particular case of rink hockey, still scarce scientific literature, when compared with other teams sports, such as, basketball (Vaquera, Santos, Villa, Morante, & García-Tormo, 2015; Ferreira, Volossovitch, & Sampaio, 2014; Courel-Ibáñez, McRobert, Toro, & Vélez, 2017), futsal (Sarmento et al., 2016; Vicente-Vila & Lago-Peñas, 2016; Almeida, Sarmento, Kelly, & Travassos, 2019), football (Sarmento et al., 2017; Carling, Wright, Nelson, & Bradley, 2014; Reilly, Bangsbo, & Franks, 2017), handball (Hassan, Schrapf, & Tilp, 2017; Póvoas et al., 2014; Massuça, Fragoso, & Teles, 2014) rugby (Durguerian, Piscione, Mathieu, & Lacome, 2019; King, Jenkins, & Gabbett, 2009; Villarejo, Ortega, Gómez, & Palao, 2014) and ice hockey (Kutáč & Sigmund, 2015; Sigmund, Kohn, & Sigmundova, 2016; Sherar, Baxter-Jones, Faulkner, & Russell, 2007).

At the beginning of the century, most of the published literature was historical reviews or specific studies devoted to the characterisation of physiological demands of training and competition (Kingman & Dyson, 2001). Since then, the research evolved to the development of studies oriented to the description and explanation of the morphological and physiological demands, talent identification and dietary intake and body composition (Castanheira et al., 2017; Hoppe et al., 2015; Valente-dos-Santos et al., 2014; Valente-dos-Santos et al., 2013; Yagüe, Del Valle, Egocheaga, Linnamo, & Fernández, 2013; Coelho-e-Silva et al., 2012; Silva, & Silva, 2017), as well to the match analysis (Arboix-Alió & Aguilera-Castells, 2019; Ferreira et al.,

2019; Oliveira, Clemente, & Martins, 2015; Sousa, Sarmento, Marques, Field, & Vaz, 2020; Trabal, Daza, & Riera, 2019).

Since 2001, some researchers provided more detailed information concerning the game focusing on the description and characterisation of the collective behaviours and activity profile of teams and players. Within those studies researchers sought to study variables such as ball possession (Ferreira, 2003; Duque, 2004; Ferreira, 2005; Clérigo, 2006; Rosa, 2006; Vaz, 2011; Valente-dos-Santos, 2006; Mendo & Anguera, 2002), type of attack (Valente-dos-Santos, 2006; Ferreira, 2005; Clérigo, 2006; Rosa, 2006; Vaz, 2011; Ferreira, 2003; Duque, 2004; Vaz et al., 2016), finishing actions (Ferreira, 2003; Duque, 2004; Vaz, 2011; Sousa, Sarmento, Marques, Field, & Vaz, 2020) and, players and goalkeepers activity (Fernandez et al., 2020; Fernández, Varo, et al., 2020; Sousa et al., 2020; Bastos, 2005; Kingman & Dyson, 1997; Kingman & Dyson, 1997b, 2001). Also, since then, researchers focused on associating players' activity and performances according to their position (Kingman & Dyson, 1997; 1997b), in situational variables such as match half, phase of the competition, game result and home advantage (Kingman & Dyson, 1997b; Sousa, Sarmento, Marques, Field, & Vaz, 2020; Bastos, 2005; Rosa, 2006; Duque, 2004; Ferreira, 2003; Arboix-Alió, Buscà, Trabal, Aguilera-Castells, & Sánchez-López, 2020) and also, comparing the differences between age groups (e.g. U-13; U-15; U-17; U-20, and; seniors) (Oliveira, Clemente, & Martins, 2015; Valente-dos-Santos, 2006; Vaz, 2011). These investigations provide important information regarding the game, but they don´t describe where, how, when and why players should perform certain actions depending on the contexts and how coaches perceive this information (Sarmento, 2012). Additionally, most of the studies that analyse the game of rink hockey are academic works that never been published in international scientific journals, limiting access to the knowledge produced.

Despite the recognised importance of the rink hockey goalkeeper, there is a dearth of literature focused only on this specific position (Mori, 1988, 1991; Kingman & Dyson, 2001; Trabal, 2016; Trabal & Riera, 2020; Trabal, Daza, & Riera, 2019). Those investigations are mainly focused on the specificity of the physical training of the goalkeeper, the activity profile during the game and also on the perception of the

hockey community (e.g., fans, players, coaches) about the relevance that a good goalkeeper has on teams' success.

To be a rink hockey goalkeeper implies to have quick reactions, good mobility, endurance and strength, whilst restricted by protective gear and adopting a crouched position (Sousa, Sarmento, Harper, Valente-dos-Santos, & Vaz, 2018; Kingman & Dyson, 2001; Mori, 1991). Therefore, they must adopt a position in the goal that allows them to carry out defence actions with the highest efficiency and the least expenditure of energy possible (Porta & Mori, 1987; Caramés, 1995). Associated to a good position in the goal, the goalkeeper needs to use the most adequate technique. In this way, combining appropriate posture and techniques, rink hockey goalkeepers will be more prepared for the demands of the game. However, lacks information about goalkeepers' techniques and positions adopted, anthropometric characteristics' and differences according to their competitive level; how goalkeepers' performance is influenced by the opposition's offensive play and the relevance given to the rink hockey goalkeeper by coaches. In this sense, it is important to bring scientific research closer to the needs of coaches in order to improve practice and also match preparation (Carling et al., 2014; Sarmento, Bradley, & Travassos, 2015).

Taking into account the previously postulated, it is evident that there is a need for studies to evolve and to understand coaches' needs and perceptions. Thus, in this study, and through the use of questionnaires and semi-structured interviews, we appealed to the knowledge of the game of rink hockey coaches and rink hockey goalkeepers, to overcome the previously mentioned limitation.

Questionnaires used as a data collection instrument allow researchers to collect information from a large number of individuals and standardise the evaluation. Additionally, the information obtained will be accurate and impersonal (Bell, 1997). Also, the use of semi-structured interviews with rink hockey coaches is justified by the need for the complementarity of the methodological approaches of this study, thus allowing a thorough knowledge of the perception that the high-level coaches interviewed have about the results obtained. In this study, the semi-structured interviews were designed to identify the most relevant issues to coaches in the tasks of preparation/observation, training intervention and also the bespoken position of rink hockey goalkeeper.

Due to the scarcity of studies in the literature focusing rink hockey and in particular rink hockey goalkeeper, the purpose of this Thesis is to contribute to the advance on practical and theoretical understanding, as well as empirical evidence regarding the rink hockey goalkeeper as well about the performance demands of the game.

1.1. Study problem and objectives

Performance analysis evolved from simple statistical analysis done manually to sophisticated analysis software that helps coaches and researchers to develop a deeper knowledge of the game (Almeida et al., 2019; Butterworth, Turner, & Johnstone, 2012; O'Donoghue, 2009b; Sarmento et al., 2015). Collecting information from the game helps coaches providing objective feedback, develop a deeper knowledge of opponent/own teams and players while enabling technical, tactical, psychological and physical development (Almeida et al., 2019; Butterworth et al., 2012; Groom & Cushion, 2004). However, it is still inconclusive that the application of performance analysis causes a significant improvement in performance since it depends on how and on the quality of the information transmitted (Butterworth et al., 2012).

Rink hockey is a fast game where most of the offensive actions are performed in short periods (Clérigo, 2006; Duque, 2004; Ferreira, 2005; Ferreira, 2003; Rosa, 2006; Valente-dos-Santos, 2006; Vaz, 2011) and where almost half of those offensive actions end with a shot on goal (Ferreira, 2003). Considering the characteristics of the game previously stated, the goalkeeper has a fundamental role in the sport's success of a rink hockey team (Trabal, 2016). However, there is still scarce number of scientific publications that focuses only on the rink hockey goalkeeper in particular concerning goalkeepers' performance and how it is influenced by the opponents' offensive process, body composition and how coaches perceive their relevance and performance. In this sense, and since there is still a lag between research and practice, it is essential to receive feedback from coaches to eventually improve practice and match preparation (Carling et al., 2014; Sarmento et al., 2015; Sarmento, Pereira, Campaniço, Anguera, & Leitão, 2013). Therefore, the overall purpose of this thesis is to gain a deeper understanding of the rink hockey goalkeeper and also of the performance demands of the game.

The conceptual framework presented above served to support the construction of the research problems of the present study, which are configured in the following questions:

1. Taking into consideration the specificity of the position, what are the anthropometric characteristics of rink hockey goalkeepers? Are there differences according to their competitive level?
2. What is the most appropriate nomenclature for the different techniques used by rink hockey goalkeepers? How can one classify the different techniques based on the type of position adopted in the goal?
3. Is the performance of rink hockey goalkeepers influenced by the opponents' attacking play? What are the most effective techniques?
4. What aspects do coaches consider to be most important to analyse? How are they organised objectively to plan this observation and how does this work influence their intervention?

Due to the stated research problems, the general objectives of this study are:

1. Systematically review and organise the literature devoted to match analysis in rink hockey;
2. Develop and validate an observational instrument tool to analyse the activity of rink hockey goalkeepers;
3. Evaluate the anthropometric characteristics of male rink hockey goalkeepers and compare the variation according to their competitive level (international vs. non-international);
4. Analyse the activity and performance of rink hockey goalkeepers and assess whether the opponent's attacking play has any relationship with their performance;
5. Explore the perceptions of rink hockey coaches concerning the observation of the opponent/own team, intervention and adaptation of training practices and the bespoke position of the rink hockey goalkeeper.

1.2. Outline of the Thesis

The current thesis is presented in manuscripts format and is organized in three

sections. The first section comprises a general introduction (Chapter 1). This chapter is identified, with the introduction, within which the theoretical framework that led to the realization of this study is materialized, and its relevance as well as its objectives and structuring.

The second section comprises the five studies of this Thesis (Chapters 2, 3, 4, 5 and, 6). In the chapter two (study 1), we systematically reviewed and organised the available literature on match analysis in rink hockey accordingly to PRISMA guidelines. Also, in this section, is included the second study of this Thesis (chapter 3), where we developed and validated an observational instrument tool to analyse the activity of rink hockey goalkeepers. The fourth chapter includes a study through which we investigated the activity and performance of the rink hockey goalkeeper and assessed whether the oppositions attacking play has any relationship with goalkeeping performance. The fifth chapter comprises a study through which we analysed and compared the anthropometric characteristics of male rink hockey goalkeepers accordingly to their competitive level (international vs. non-international). The sixth chapter contains a study through which, by the use of semi-structured interviews, we sought to access the perceptions of rink hockey head coaches in relation to the preparation/observation, intervention and adaptation of training exercises and also the bespoke position of the rink hockey goalkeeper.

Finally, Section 3 (Chapter 7) where the final considerations of this Thesis are presented and the findings of the different studies are summarized and put into context and their implications argued. The third section comprises the seventh chapter where we presented the conclusions of the work resulting from the partial conclusions of the studies carried out. In this sense, the results obtained are related and synthesized, in order to obtain an integrated view of the conclusions of the different studies. Suggestions are also made that can substantiate future academic work involving this theme.

SECTION II

CHAPTER TWO: Study One

2. Match analysis in rink hockey: a systematic review

Reference: Sousa T., Sarmento H., Harper L. D., Valente-dos-Santos J., Vaz V. (*under review*). "Match analysis in Rink Hockey: A systematic review" *Montenegrin Journal of Sports Science and Medicine.*

2.1. Abstract

Match analysis has gained a prominent place in the scientific literature; however, research devoted to match analysis in adult male rink hockey is still limited. The purpose of this paper was to review the available literature on match analysis in rink hockey.

A systematic review of *Web of Science*, *Sportdiscus*, *Pubmed*, *Scopus*, *B-on* and *RCAAP* was performed accordingly to PRISMA guidelines. The following keywords written in English and Portuguese were used: "roller hockey" and "rink hockey", each one associated with the terms: "match analysis", "performance analysis" and "game analysis". Of the 1785 studies initially identified, 20 studies received further in-depth reading and analysis for the systematic review.

This review highlights that rink hockey could be characterised as a sport where half of the offensive actions end with a shot at goal, but only a small number of these shots end with a goal. Furthermore, there are differences in technical demands between player position and reductions in movement intensity in the second half of matches compared to the first half.

According to the limitations of the reviewed studies, future research should provide more scientific knowledge on the sport, using new technologies and new approaches in the study of tactical sequential events.

Keywords: roller hockey; game analysis; performance analysis; team sports.

2.2. Introduction

Increased utilisation of technology and application of empirical data can enhance the development of a sport and improve athletic performance (Gayo, 2000). There is a broad range of resources and methods used by coaches and researchers to increase their knowledge and improve the quality of players and teams (Garganta, 2001). To better understand the constraints that can negatively impact sporting success, match analysis has assumed a significant role (Carling, Reilly, & Williams, 2008; Garganta, 2001).

It was in the English county of Kent in 1926 that the first European men's hockey skating championship was carried out, with the first World Championship held in 1936 in the city of Stuttgart (Oliveira, 2012). In 1992 at the Olympic Games in Barcelona it was presented as a demonstration sport. However, it was not accepted as an official sport. Despite this setback, the sport did not stop expanding and today is played in 30 countries over five continents. As of 2014, there were 833 registered clubs and 4626 teams playing rink hockey (Rinkhockey.net, 2014).

Much of the knowledge of rink hockey is adapted from other sports, which have distinct differences. This lack of systematic and consistent theoretical and practical background makes it harder to provide useful information for coaches (Gayo, 2000). The scientific research carried out in rink hockey is minimal and to the best of our knowledge, only one study has been performed to summarise and review the available roller hockey literature (over 19 years ago; Kingman & Dyson, 2001). In this article, the authors concluded that much of the published literature was historical reviews of the sport or specific studies devoted to the characterisation of physiological demands of training and competition. Since this review, some crucial studies have been carried out on topics such as: (1) morphological and physiological demands (Valente-dos-Santos et al., 2014; Valente-dos-Santos, Sherar, et al., 2013; Yagüe, Del Valle, Egocheaga, Linnamo, & Fernández, 2013; Hoppe et al., 2015); (2) talent identification (Coelho-e-Silva et al., 2012); and, (3) dietary intake and body composition (Silva & Silva, 2017).

Although there is an increase in the number of research papers devoted to this specific sport, there is no published review of the available literature on rink hockey match analysis, despite similar reviews available in sports such as football (Sarmento et al., 2014; Sarmento, Clemente, et al., 2018), futsal (Agras, Ferragut, & Abraldes, 2016), handball (Prieto, Goméz, & Sampaio, 2015), volleyball (Silva, Marcelino, Lacerda, & João, 2016) and basketball (Courel-Ibáñez et al., 2017). A systematic review of the available literature in rink hockey on match analysis may help coaches and practitioners to better understand the most common research topics and the demands of the sport. Therefore, the purpose of this study was to systematically review and organise the literature devoted to match analysis in rink hockey.

2.3. Methods

Search strategy: databases, inclusion criteria and process of selection

A review of the available literature was conducted according to PRISMA (Preferred Reporting Items for Systematic reviews and Meta-analyses) guidelines. Two independent reviewers separately (TS and VV) conducted the analysis performed on July 24th, 2020. Electronic databases *Web of Science*, *Sportdiscus*, *Pubmed*, *Scopus*, *B On* and *RCAAP* (Open Access Scientific Portuguese Repository) were researched for relevant publications using the keywords, "Roller Hockey" and "Rink Hockey" each one associated with the terms "Match analysis", "Performance analysis" and "Game analysis".

Inclusion criteria for scientific publications were: (1) written in English or Portuguese; (2) contained relevant data about match analysis in rink hockey; (3) published as original papers, reviews, book chapters, academic works (such as PhD. dissertations, master thesis, etc.). All the publications that did not meet the inclusion criteria were excluded from this review.

If there was disagreement amongst authors regarding the inclusion of specific articles, the final decision was left to the senior author (JVS). Studies were assembled according to the primary research topics of match analysis and the methodological strategies used.

Extraction of data and quality of the studies

To evaluate the quality of the studies, a risk-of-bias quality form was adapted from Sarmento, Anguera et al.(2018) and Sarmento, Clemente et al. (2018) to evaluate qualitative and quantitative publications.

Quantitative studies were assessed based on 16 items: purpose (item 1), the relevance of background literature (item 2), appropriateness of study design (item 3), the sample studied (items 4 and 5), use of informed consent procedure (item 6), outcome measures (item 7 and 8), method description (item 9), the significance of results (item 10), analysis (item 11), practical importance (item 12), description of drop-outs (item 13), conclusions (item 14), practical implications (item 15) and limitations (item 16). All sixteen quality criteria were scored on a binary scale (0/1), wherein two of those criteria (items 6 and 13) presented the option: "If not applicable, assume NA". Qualitative studies were assessed based on 21 critical components: objective (item 1), literature review (item 2), study design (items 3, 4 and 5), sampling (item 6, 7, 8 and 9), data collection (descriptive clarity: items 10, 11 and 12; procedural rigor: item 13), data analysis (analytical rigor: items 14 and 15; auditability: items 16 and 17; theoretical connections: item 18) and overall rigor (item 19) and conclusion/implications (items 20 and 21).

As in previous research (Sarmento, Clemente, et al., 2018; Sarmento, Anguera, et al., 2018), and to make a fair comparison between studies of different designs, the decision was taken to calculate a percentage score as a final measure of methodological quality. This final score is the result of the sum of every score in a given study divided by the total number of items for that specific research design (i.e*.,* 16 or 21). Articles were classified as: (1) low methodological quality - with a score ≤50%; (2) good methodological quality - between 51% and 75%, and; (3) excellent methodological quality - with a score >75% (Sarmento, Anguera, et al., 2018). One author extracted the data (TS), and another verified it (JVS), with disagreements resolved in discussions between these two authors. The versions of the Critical Review Forms used in this study can be found in the Electronic Supplementary Material Table S1 and S2.

2.4. Results

Search, selection and inclusion of publications

The research performed on the database allowed us to identify 1789 publications. These data were then exported to reference manager software (EndNote X8), and any duplicates (928 references) were eliminated automatically. The remaining publications (857) were then screened according to the title and abstract for relevance, resulting in another 799 studies being removed from the database. The full texts of the remaining 58 publications were read, and another 38 were rejected due to a lack of relevance to the purpose of this review (Table 2.1). The reason for the exclusion of publications was that the publication did not concern match analysis (33 publications excluded) or it was not written in English or Portuguese (5 publications excluded).

At the end of the screening procedure, 20 publications (eleven original papers, one PhD. dissertation, two master's thesis and seven graduate theses) received further in-depth reading and analysis for the systematic review. From these 20 publications, nine were written in Portuguese and eleven in English.

To organise the results of this review, we categorised material as a function of two levels of analysis, as suggested by Sarmento et al. (2014): a first-order level, dependent on the type of analysis performed (descriptive analysis and comparative analysis); and a second-order level, based on the type of variables analysed (Figure 2.2). The aim was not to produce categories that were mutually exclusive as the same analyses can include topics that relate to different categories. Thus, a study included in a specific “category”, could also be classified in another “category” if the content justified its inclusion.

Quality of the studies

The quality of indicators for the studies included in this review was: (1) the average methodological quality score for the 20 selected studies was 69.1%; (2) none of the studies achieved 100%; (3) none of the studies scored below 50%; (4) eight studies scored equal or higher than 75% (excellent methodological quality); (5) 12 studies scored below 75% but higher than 56% (good methodological quality).

Some of the limitations identified in the reviewed studies were: (1) some studies did not report an explicit justification of the sample size; (2) most of the studies did not indicate that informed consent was obtained for each participant of the study.

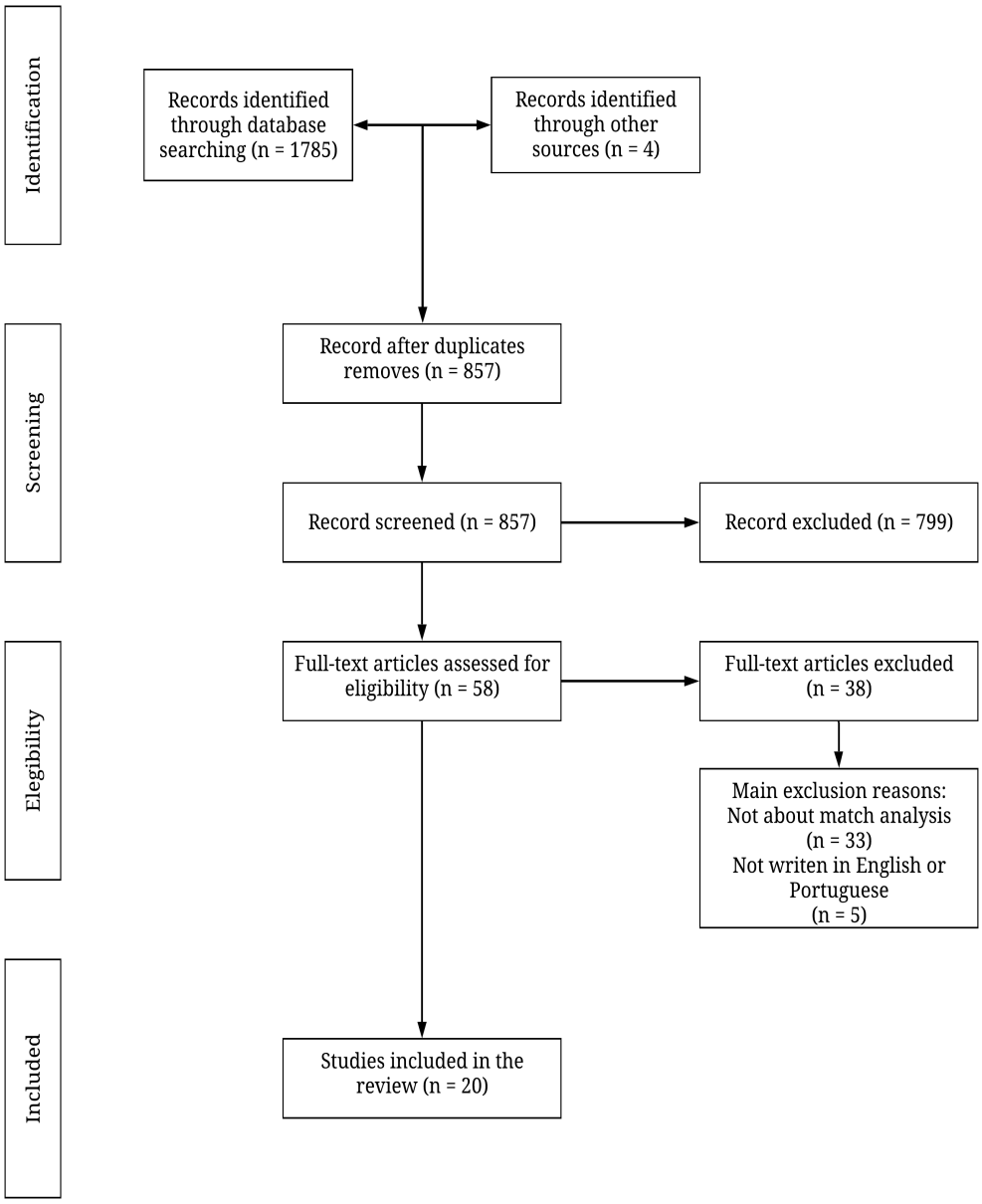

Figure 2.1 Flowchart of the methodology used for search.

General limitations of the reviewed studies

Some of the limitations of the reviewed studies were: (1) most of the studies were written in Portuguese, which limits the international dissemination of information; (2) only half of the twenty studies reviewed were published in international journals; (3)

most of the studies were published prior to 2009 (60%). In 2009 there were profound changes to the rules of the game, which may limit the applicability of data published prior to the rule change; (4) rink hockey has a low number of publications related to match analysis; (5) only one of the studies uses recent technology (e.g., Global Positioning Systems) to analyse and the activity profile of players.

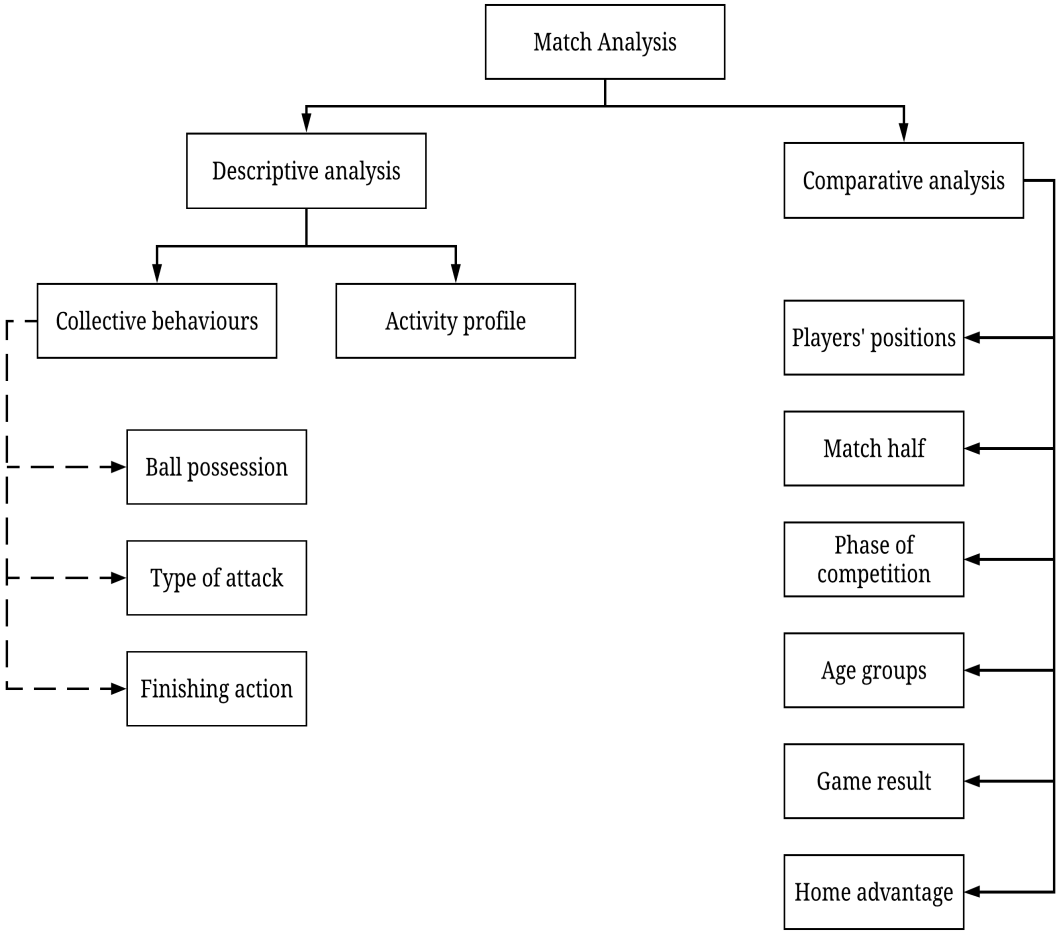

Figure 2.2 Scope of match analysis.

Major research topics

After in-depth analysis, it was decided to categorise the results into descriptive analysis and comparative analysis. Within the descriptive analysis, the results were presented in two major categories: (1) collective behaviours and (2) activity profile. The category "collective behaviours" was presented in three topics: (1) ball possession; (2) type of attack, and (3) finishing action. Within the comparative

analysis, the results were presented using five topics: (1) player position; (2) match half; (3) phase of competition; (4) age groups, (5) game result, and (6) home advantage.

2.5. Descriptive analysis

The common aim of these reviewed studies was to characterise the game of rink hockey through the description of collective behaviours or activity profile (Table 2.1). However, there are some exceptions (e.g., Ferreira, 2003; Duque, 2004; Rosa, 2006), where authors compared winning teams with losing teams in addition to the descriptive analysis.

Within descriptive approaches, most of the researchers sought to study age-related differences, in under-17 (U-17) (Rosa, 2006; Duque, 2004; Vaz, 2011) under-20 (U-20) and senior players (Ferreira, 2005; Clérigo, 2006; Ferreira, 2003; Sousa, Sarmento, Marques, Field, & Vaz, 2020; Fernandez et al., 2020; Fernández, Varo et al., 2020). In these studies, the authors focused their attention mainly on: (1) ball possession (Ferreira, 2003; Duque, 2004; Ferreira, 2005; Clérigo, 2006; Rosa, 2006; Vaz, 2011; Valente-dos-Santos, 2006; Mendo & Anguera, 2002); (2) type of attack (Valente-dos-Santos, 2006; Ferreira, 2005; Clérigo, 2006; Rosa, 2006; Vaz, 2011; Ferreira, 2003; Duque, 2004; Vaz et al., 2016); (3) finishing actions (Ferreira, 2003; Duque, 2004; Sousa, 2014; Vaz, 2011; Sousa, Sarmento, Marques, Field, & Vaz, 2020) and; (4) activity profile (Fernandez et al., 2020; Fernández, Varo et al., 2020; Sousa et al. 2020; (Bastos, 2005; Kingman & Dyson, 1997; Kingman & Dyson, 1997b, 2001) (Table 2.1).

To better understand where interactions are performed by rink hockey players Vaz et al., 2016) delineated the rink hockey field into 18 zones (Figure 2.3).

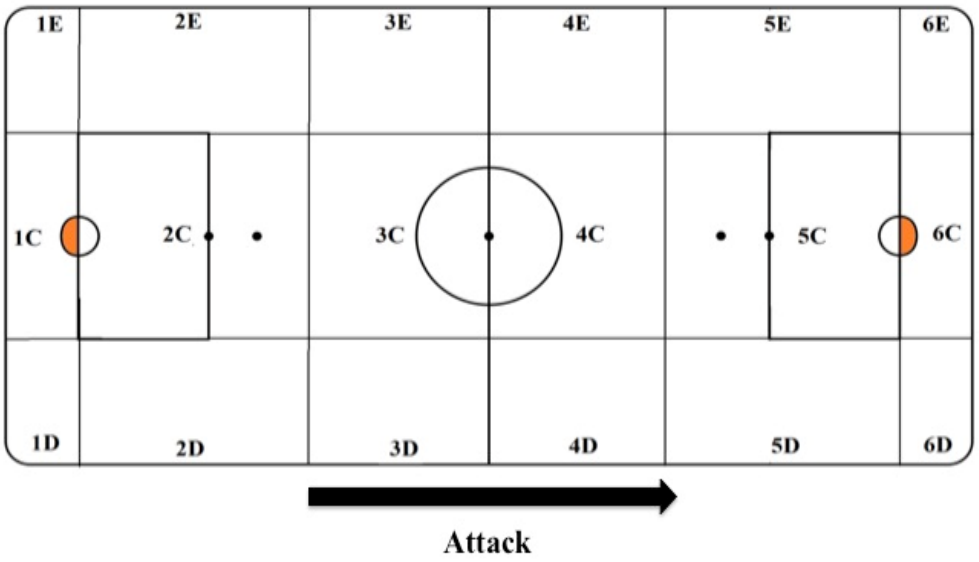

Figure 2.3 The rink hockey field divided into 18 areas in three corridors (E – left; C – central; D – right), (Vaz et al., 2016).

Table 2.1 Studies with predominantly descriptive analysis.

Study	**Sample**	**Variables**	**Main Results**	**Quality score (%)**
Kingman & Dyson (2001)	- England National Team and five national premier league teams; - Six matches;	- Activity profile;	The most considerable amount of goals was scored in the top right of the goal. Usually, goalkeepers are thought to be weaker on the top right of the goal, because of the use of the stick. Goalkeepers' are thought to be less mobile on the side of the hand that holds the stick.	56.3
Mendo & Anguera (2002)	- Six premier division matches involving a total of six different teams; - 66 professional players from the Spanish premier division;	- Ball possession;	The description and interpretation of patterns of play also have implications for psychosocial intervention. The study of the patterns shed light on the behavioural development of real play and thus determine both the intervention at each link in the behaviour chain and the consideration of intervention techniques or strategies suited to improving players resources.	68.8

Table 2.1 Studies with predominantly descriptive analysis (cont.).

Study	**Sample**	**Variables**	**Main Results**	**Quality score (%)**
Ferreira (2003)	- Five teams from the elite Portuguese Premier League; - Four matches from seasons 2000/2001, 2001/2002 and 2002/2003;	- Ball possessions; - Type of attack; - Finishing action; - Game result	The actions that create ball possession are tackles, missed shots and shots at goal not scored. Most ball possessions begin in defensive areas. Counter-attacks and fast attacks begin after a mistake from the opponent, while the organised attack normally begins after a shot. There are no differences between winners and losers when ball possession is considered. Winners tend to perform more counter-attacks and organised attacks.	62.5
Duque (2004)	- European Championship U17; - Five National teams; - Four matches analysed;	- Ball possessions; - Type of attack; - Game result;	The most frequent ways of regaining ball possession are faults and defensive recovery. In every phase of the game, the beginning of the ball possession starts in defensive areas and the intermediate area of the field. Counter-attack begins 87% of the time after a mistake from the opponent, while fast-attacks and organised attacks tend to be initiated after a fault, offensive rebound or goal. Organised attacks are the phases of the game were the effectiveness index is lowest.	62.5

Table 2.1 Studies with predominantly descriptive analysis (cont.).

Study	Sample	Variables	Main Results	Quality score (%)
Ferreira (2005)	- European Championship U20 - Four matches	- Ball possessions - Type of attack	The most common way of regaining ball possession is through faults and defensive recovery. The action of ball recovery that most commonly precedes a counter-attack is tackle while the origin of fast-attacks is typically defensive recovery. An intercepted pass is the most critical action that precedes an organised attack. Counter-attacks end mainly with a shot at goal, and the end of ball possession occurs mostly in the offensive central area and due to tackles. In situations of an organised attack, the end of ball possession is usually due to faults.	62.5
Clérigo (2006)	- U20 Portuguese rink hockey teams - Four matches	- Ball possessions - Type of attack	The actions that causes regain of ball possession are defensive recovery, faults and tackles. Tackles play an important role at the beginning of a counter-attack, whilst defensive recovery is the most crucial action before a fast attack. 35% of organised attacks are initiated after a fault. Shots at goal are the most frequent offensive action associated with the end of ball possession during counter-attacks and fast-attacks. In situations of organised attacks, faults are the action most commonly associated with the end of ball possession, followed by shots.	62.5

Table 2.1 Studies with predominantly descriptive analysis (cont.).

Study	**Sample**	**Variables**	**Main Results**	**Quality score (%)**
Rosa (2006)	- Final Four U17, 2005/2006 - Four teams - Four matches	- Ball possessions - Type of attack - Game result	The actions that lead to the beginning of ball possession are defensive actions of defensive recovery, followed by faults and then offensive recovery. Teams start ball possession in the defensive area. Tackles are the most critical actions during the beginning of counter-attacks and fast-attacks, while organised attacks develop after faults and shots at goal. Winning teams prefer fast-attacks and counter-attacks while losing teams have more ball possession.	62.5
Ferreira (2008)	- Ten games from first Portuguese league in 2007/2008 between teams that had qualified for the play-offs	- Finishing action	Offensive decisional behaviour influences the efficiency of finalisation actions, with linear actions developing into ball control and non-linear actions developing into shooting actions.	56.3
Vaz (2011)	- U17 Portuguese national team - International competition	- Ball possessions and type of possession - Type of attack - Finishing action - Age groups	Characterisation of game systems of the Portuguese U17 National Team.	93.8
Sousa (2014)	- Rink hockey managers	- Finishing action	This study sought to examine which parameters are considered most relevant in observation and analysis of the performance of the teams and athletes by Rink Hockey Managers.	80.9

Table 2.1 Studies with predominantly descriptive analysis (cont.).

Study	**Sample**	**Variables**	**Main Results**	**Quality score (%)**
Vaz et al. (2016)	- Eight rink hockey players from the U-17 Portuguese national team	- Type of attack	The results permitted the identification of the centroid player and his role in team activity and concluded that rink hockey could be described as an open system able to create clusters of connectivity between players.	75
Fernández, Novelles et al. (2020)	- Eight professional rink hockey players	- The distance covered in high-speed skating.	The results show that training drills could not reproduce the maximum conditional effort that occurs in an official match in any time window. Moreover, all the situations and games analysed had higher levels of effort as the time of the window studied decreased.	71.4
Sousa et al. (2020)	- 1713 shots at goal from the 2016/2017 season in the Portuguese Rink Hockey First Division.	- The variables were divided into four categories: (1) context of attacking play; (2) beginning of attacking play; (3) development of attacking play, and (4) end of attacking play.	- Goalkeepers are more effective in the first half versus the second half of the matches. Goalkeeping performance was also lower in the direct free-hits and penalties when compared with indirect free-hits. The technique most used by the rink hockey goalkeepers to save shots at goal is the "knee on the floor". Observations demonstrate that when the attack begins in the opposition defensive area, teams are 55% more likely to score. The shots at the upper zones of the goal have a higher probability of being successful.	85.7

Table 2.1 Studies with predominantly descriptive analysis (cont.).

Study	Sample	Variables	Main Results	Quality score (%)
Fernández, Varo et al. (2020)	- Eight professional rink hockey players	- The following variables were calculated: (1) distance travelled in meters; (2) distance covered above 18 km/h in meters; (3) player load, vector magnitude; (4) number of high-intensity accelerations, and (5) number of high-intensity decelerations.	Regarding external load competitive demands, the distance travelled data from this study places rink hockey behind outdoor sports. The distance travelled by minute from the players analysed is higher than other players from other indoor sports. There is no difference between interior and exterior players in terms of external load.	71.4

2.6. Comparative analysis

Researchers sought to explain players' activity and compare performances according to: (1) players position (Kingman & Dyson, 1997; 1997b); (2) match half (Kingman & Dyson, 1997b; Sousa, Sarmento, Marques, Field, & Vaz, 2020); (3) phase of the competition (Bastos, 2005); (4) age group (Oliveira, Clemente, & Martins, 2015; Valente-dos-Santos, 2006; Vaz, 2011); (5) game result (Rosa, 2006; Duque, 2004; Ferreira, 2003; Kingman & Dyson, 1997b) and; (6) home advantage (Arboix-Alió et al., 2020) (Table 2.2).

2.7. Discussion

The purpose of this paper was to review the available literature on match analysis in rink hockey. In the following sections, we discuss the most pertinent results emerging from the studies reviewed.

2.8. Descriptive analysis

The descriptive studies reviewed in the next sections of this paper characterise the game of rink hockey by describing collective behaviours or activity profile.

Collective behaviours

Ball possession

Through the reviewed studies, we concluded that most of the offensive actions are performed in short periods, which leads to a high number of ball possessions per game (range: 55.6 to 105.5). Additionally, there are differences regarding ball possession between the top four teams of the U-17 Portuguese league and the U-17 Portuguese national team (Duque, 2004; Vaz, 2011). The analysis of the top four U-17 teams of the Portuguese league revealed that, on average, each team has 105.5 ball possessions per game (Rosa, 2006). This number of ball possessions is substantially higher than those performed by the U-17 Portuguese national team (Duque, 2004; Vaz, 2011). Duque (2004), observed a total of 520 ball possessions (across the four games analysed) corresponding to 65 ball possessions per team, while Vaz (2011), estimated 55.6 ball possessions per game. The differences observed between the two aforementioned studies might be explained by the changes introduced to in-game rules in 2009 (World Skate, 2018). One of the modifications was the introduction of a 45-second rule that states that after a team gains possession of the ball they have 45 seconds – timed by a "shot clock" – to finish the offensive process. The change to the rules of the game seems to have made the game more dynamic due to the reduction in the number of game interruptions. Before the World Skate (International Olympic Committee recognised organisational body for roller sports) introduced changes to the rules of the game (World Skate, 2018), many coaches used fouling as a defensive strategy to stop the opposition's offensive build-up. Nowadays these fouls count and can even lead to a temporary exclusion of a player from the game, leaving the team "short-handed", with a reduced number of active players (similar to the penalty kill in ice hockey). A longitudinal analysis could help understand the implications that the changes in the rules of the game (World Skate, 2018) have brought to rink hockey.

Table 2.2 Studies with predominantly comparative analysis.

Study	**Sample**	**Variables**	**Main Results**	**Quality score (%)**
Kingman & Dyson (1997)	- 2 Premier English Rink Hockey matches - 16 subjects were analysed (4 in each team at the time, excluding the goalkeeper)	- Players' position	Rink hockey is a fast and dynamic sport because of a significant amount of high-intensity activities and a large number of actions performed in quick succession.	62.5
Kingman & Dyson (1997b)	- Two Premier English Rink Hockey matches - 16 subjects were analysed (4 in each team at the time, excluding the goalkeeper)	- Players' position - Match half - Game result	There is a minor position effect for the type of action performed, but there is no position effect for the intensity and direction of movement in a rink hockey match, supporting the argument that there are no differences between players' positions.	62.5
Bastos (2005)	- Six games of the Portuguese National Team during the 2003 World Cup - 1vs1 actions	- Phase of the competition	The numbers of goals scored in situations of 1vs1 are higher in the group phase in comparison with the knockout phase. The type of dribble more often used is the dribble in progression. After 1vs1, teams often keep possession of the ball.	62.5
Valente-dos-Santos (2006)	- Eight matches from the 2005 world cup - Data from Duque (2004) -Data from Ferreira (2005)	- Ball possession - Type of attack - Age groups	The organised attack is the primary phase of rink hockey. The central defensive area is where the majority of ball possessions begin. The senior game is characterised by a low efficiency but compared to U17 and U20 is a far more offensive game.	62.5

Table 2.2 Studies with predominantly comparative analysis (cont.).

Study	Sample	Variables	Main Results	Quality score (%)
Oliveira, Clemente, & Martins (2015)	- Fifty-four rink hockey players - Five different levels (U-12; U-14; U-16; U-18, and; elite with more than 20 years old) - Three official matches	- Age groups	The results found no statistical differences in centrality levels between different age groups. Nevertheless, differences were found between tactical positions in both centrality metrics computed in this study.	81.3
Arboix-Alió (2020)	- The sample was composed of 2080 games (1632 in men's first division and 448 in women's first division)	- Home advantage.	The home advantage was higher than 50% in both leagues, with significantly higher values in the male league. The results indicated that teams score a higher percentage of goals when playing at home, no differences were found between genders. Regarding the number of goals scored per match, the results showed differences between genders, with higher values for the men's league.	78.6

Similar results were found between the Portuguese U-20 and senior teams. They performed, on average, 201 ball possessions per game, which represents an average of 100 ball possessions per team (Ferreira, 2003; Clérigo, 2006; Valente-dos-Santos, 2006). Similar values in different age group teams could be related to the fact that both seniors and U-20 play games of 50 minutes (two halves of 25 minutes each) and also the higher technical-tactical development of the players. This observed number of ball possessions per team is higher than the 76 ball possessions per game performed by the Portuguese national team during the U-20 European championship (Ferreira, 2005). However, caution should be taken when analysing these results as games at the European Championships had a total duration of 40 minutes (two halves of 20 minutes each).

Concerning defensive actions, it has been previously suggested that there is an association with these types of behaviour and the end of an offensive action (Mendo & Anguera, 2002). The reviewed studies suggested that this is the same for all age groups. Ball possession is regained mainly by the successful execution of defensive actions (such as duel, interception, recovery of ball possession after a save from the goalkeeper) or due to the laws of the game (such as ball out, faults) (Duque, 2004; Rosa, 2006; Clérigo, 2006; Ferreira, 2005; Valente-dos-Santos, 2006; Mendo & Anguera, 2002; Ferreira, 2003). Mendo and Anguera (2002) confirmed this tendency through the study of patterns of play in high-level rink hockey teams, concluding that a shot on goal or a goal scored is related to specific patterns of defensive organisation and mainly related to the way the ball is regained (direct or indirect recovery of ball possession). As rink hockey is characterised by the low effectiveness of the offensive process despite the high number of ball possessions per game, the ability to recover ball possession after a shot on goal is one of the most important actions during a game. In this sense, all the players have a fundamental role in this moment of the game, and not only the goalkeeper, due to the specific dynamic of this sport. However, Mendo and Anguera (2002) highlighted the importance of the goalkeeper's actions. After a save from the goalkeeper, defensive patterns of ball recovery emerge from both teams.

Across all age groups, the defensive and intermediate areas of the rink (zones 1, 2, 3 and 4) (Figure 2.3) are the preferential areas to start offensive actions (Duque, 2004; Rosa, 2006; Clérigo, 2006; Ferreira, 2005; Ferreira, 2003). The reviewed studies indicated that in every age group (U-17, U-20 and seniors) ball possession started preferentially in defensive and intermediate areas. However, some offensive sequences started in the last offensive third (zones 5 and 6) (see Figure 2.3) (Duque, 2004). In sports like football (Sarmento, Figueiredo, et al., 2018), regaining possession of the ball in more offensive areas is related to increased effectiveness of the offensive process. In the reviewed studies on rink hockey, this type of relationship has not been studied and should be one of the variables analysed in future studies. Although there are no studies that relate ball regained possession with the effectiveness of the offensive process on rink hockey, Rosa (2006) concluded that the area of the rink where ball possession starts could be associated with the type of

defensive organisation adopted by the team in the defensive process, or the strategy employed by teams and managers.

Type of attack

Rink hockey is a fast game where offensive actions tend to occur over a duration of fewer than nine seconds (Valente-dos-Santos, 2006; Ferreira, 2005; Clérigo, 2006; Rosa, 2006). On average, a rink hockey team needs approximately three to eight seconds to complete a counter-attack (Ferreira, 2005; Clérigo, 2006; Rosa, 2006) while organised attacks, on average, do not extend beyond nine seconds (Ferreira, 2005; Clérigo, 2006; Rosa, 2006).

Although being a fast game, a more organised build-up style of play is the preferred offensive method across all age groups. An analysis of the offensive organisation of the U-17 Portuguese national team reveals that time spent on organised attacks was higher (73.7% of total playing time) compared to counter-attacks (Vaz, 2011). On average, the time in ball possession by the Portuguese national team was 1136 seconds (63%) and the average time spent in sector 5 (front of the goal) and 6 (behind the goal) was 518 seconds, while the time spent in sector 4 (intermediate zone) was 393 seconds. More recently, Vaz et al. (2016) concluded that there is a predominance of offensive midfield interactions, particularly in sector 4 and finalisation in 5C (see Figure 2.3).

Offensive or defensive recovery of the ball (e.g., tackle, shot at goal, fault, intercepted pass) is associated with the start of an organised attack (Rosa, 2006; Duque, 2004; Clérigo, 2006; Valente-dos-Santos, 2006; Ferreira, 2005; Ferreira, 2003). Tackles and opponent mistakes are the predominant actions that precede a counter-attack (Ferreira, 2005; Rosa, 2006; Clérigo, 2006; Valente-dos-Santos, 2006; Ferreira, 2003; Duque, 2004). Moreover, and less frequently, missed goals, recovery of ball possession and intercepted passes are also actions that precipitate offensive sequences of a counter-attack.

With regards to situations that lead to fast-attacks, the most common behaviours are shots on goal and actions of defensive recovery of ball possession (Clérigo, 2006; Ferreira, 2005; Valente-dos-Santos, 2006; Rosa, 2006). Additionally, events such as

faults, ball recovery in offensive midfield, offensive mistakes and even the scoring of goals appear to be related with this type of offensive organisation (Duque, 2004; Valente-dos-Santos, 2006; Ferreira, 2003).

Counter-attacks and fast-attacks are frequently ended with a shot on goal (Clérigo, 2006; Ferreira, 2005), while organised attacks tend to be stopped by the opponent team through a fault or by a shot on goal by the team in possession of the ball (Clérigo, 2006). Concerning the areas where attacks are concluded, counter-attacks and fast-attacks tend to end in the central offensive area, while organised attacks frequently end in both offensive lateral corridors, and less frequently in the intermediate offensive area (Ferreira, 2005).

Finishing action

In rink hockey, almost half of the offensive actions end with a shot on goal (48%), while in floorball the total is 42% (Miguel Angel Gómez, Prieto, Pérez, & Sampaio, 2013), and only 3% of those shots end in goal scored (Ferreira, 2003). In futsal, a sport with some resemblances to rink hockey (i.e., the same number of players and similar field dimensions), a study conducted by Vicente-Vila & Lago-Peñas (2016) led to the conclusion that teams playing at home present higher values of effectiveness (17.4%) when compared with away teams (14.4%). These values of effectiveness are substantially higher than those presented by Ferreira (2003). In games between senior teams, fast-attack is the offensive game method that causes more shots on goal when related to the number of ball possessions (50%), while counter-attacks produce a lower percentage of attempted shots (41%). Fast-attacks seem to be related to a higher degree of efficiency (i.e., a goal being scored, 6%), while counter-attack and organised attack display lower efficiency values (2%) (Ferreira, 2003). The U-17 group present a different tendency as counter-attacks lead to more attempted shots when accounting for the number of ball possessions (39%) and is also the most efficient game method (17%), contrasting with organised attacks that have much lower efficiency values (5%) (Duque, 2004). These results can be explained by the tactical culture of senior players (compared with the U-17 group) preventing situations of unbalanced defensive structure.

Central areas near the goal are most frequently used by rink hockey players to finish offensive sequences as is observed in other team sports like football (Sarmento, Figueiredo et al., 2018) and futsal (Santana, Laudari, Istchuk, & Arruda, 2013; Sarmento et al., 2016). The area where a team starts the offensive process influences the effectiveness of the offensive process. When the offensive process stars in the opposition defensive area the odds of ending with a goal scored are higher than when the offensive process starts in the intermediate or in the defensive area (Sousa et al., 2020). The effectiveness of the offensive sequences is also associated with the central offensive zones, with nearly 87% of goals scored from there (Ferreira, 2003). Youth (U-17) teams presented a similar tendency with 74% of the attempted shots resulting in a goal performed in the central offensive zones. However, players tend to finish a counter-attack and fast-attack situations more frequently from a shot in the intermediate area (Duque, 2004). This result suggests that at this age, the youth players are not at an adequate technical/tactical maturity to progress to the more advanced areas of increased offensiveness where they are more likely to score a goal. Nevertheless, coaches consider it important to know the areas of the field where the percentage of effectiveness of the offensive sequences is highest, thus developing strategies to improve their players and teams (Sousa, 2014).

To characterise the offensive phase Vaz (2011) differentiated offensive actions into three types: (1) offensive actions of type I are identified as complete collective actions (with a shot at goal); (2) offensive actions of type II are identified as incomplete collective actions (without a shot at goal; e.g. loss ball, fault); (3) offensive actions of type III are identified as situations involving a set-play with the possibility of final actions (e.g. direct free-hit, penalty, indirect free-hit). Collecting the number of Type I actions throughout the game and the potential for offensive finalisation can allow an assessment of the effectiveness of a team's offensive build-up. Through the application of the offensive build-up effectiveness index and the overall finalisation index, we can get an approximate idea of the performance and attitude of a team concerning the task of offensive build-up, allowing the identification of success in this phase of the game (Vaz, 2011).

The effectiveness of the offensive phase of the Portuguese U-17 national team reveals low values of finalisation index (percentage of team's success in solving offensive

finalisation problems, evaluated from the following formula: FI = ((scored goals/number of collective actions type I and III) x 100) (11.8%) and the global finalisation index (the average ability of a team to produce finishing situations throughout the offensive phase of the game, evaluated from the following formula: GFI = sum of the brokerage indices of collective actions type I and III) (13.5%) (Vaz, 2011). The values for the index of efficiency of the offensive build-up (number of collective actions type I / number of collective actions type I and type II x 100) (64.2%) and the index of efficiency for the defensive build-up (success of a team in solving defensive problems) (55.3%), suggests a predominance of ball possession with finalisation (actions type I and III) (Vaz, 2011). The ability to cancel the offensive organisation of the opponent teams generates a positive differential of almost 10%.

Activity profile

Rink hockey players perform, on average, 1004.7 actions per game with 3.7 seconds spent on each action. Ball transfer (i.e., passing) and tackling are the most frequent actions in the game (Kingman & Dyson, 1997). Additionally, rolling is the most frequent skating activity with the most prolonged mean duration (7.6 seconds) (Kingman & Dyson, 1997) and it is in the second half that players perform the highest percentages of rolling (Kingman & Dyson, 1997b). Sprinting occurs for only 4% of game-time and is more frequent in the first half of a match (Kingman & Dyson, 1997; 1997b). In general, 22% of the match is classified as high-intensity activity and 77% classified as a low-intensity activity. Sports like field hockey (5%) (Spencer et al., 2004) and futsal (considered a high-intensity sport), (13.7%; Barbero-Alvarez, Soto, Barbero-Alvarez, & Granda-Vera, 2008) spend a lower percentage of the match in high-intensity activities. The higher percentages of low-intensity activities are spent on the second halves of the matches (Kingman & Dyson, 1997b). Similar findings were reported by Dogramaci, Watsford, and Murphy (2011) when comparing international and Australian national futsal games.

More recently, Fernández, Varo, Carmona and Reche (2020), gathered the information of external load during 9 matches of the 2017-18 season of Spanish league (Ok Liga) through a UWB positioning system. The authors collected information from 8 players and concluded that regarding external load competition

demands the distance travelled by a rink hockey player is clearly lower than outdoors sports (Clemente, Couceiro, Martins, Ivanova, & Mendes, 2013; King, Jenkins, & Gabbett, 2009). However, in another study, using the same positional system and with the same sample of players Fernández, Novelles, Tarragó, and Reche (2020), collected positional data to determinate the most demanding passages through the distance covered in high-speed skating (> 18 km · h^{-1}, m · min^{-1}) during a match, and also in training drills. The authors concluded that they couldn't reproduce the most demanding passages of the match in training situations.

The offensive area (central corridor) is where players perform situations of 1vs1 most often, and the most frequent type of dribble is the dribble in progression (technical-tactical action in which the player attempts to overtake the opponent to create a finishing action) (Bastos, 2005). The most common shot is the forehand flick shot, and this type of shot is also the shot that takes the most time to execute (Kingman & Dyson, 1997; 1997b). Kingman and Dyson (2001) concluded that goalkeepers spend substantially longer times positioned in the centre of the goal (68.7%), while only 18.6% of the time is spent on the left side of the goal and 12.7% on the right side. Rink hockey goalkeepers tend to be less effective when the shot is performed in their defensive area and to the upper zones of the goal and more effective in the middle (Kingman & Dyson, 2001; Sousa et al., 2020). While Kingman and Dyson (2001), analysing six English Premier League matches and concluded that the shots placed in the top right of the goal were more successful (38.2%), Sousa et al. (2020) analysing 1713 shots on goal from the Portuguese First Division 2016/2017 concluded that it was in the top left of the goal that the goalkeeper was less effective (35.8%). These results are in concordance with a study of Almeida, Volossovitch, and Duarte (2016), where 536 penalties from 2010 to 2015 from the UEFA Champions and Europa League (football) were analysed.

The most frequent technique used by rink hockey goalkeepers is the "knee on the floor" (Sousa et al., 2020). The author compared different techniques used by the goalkeepers and concluded that "fleck", "spatula" and "side fall" were less efficient than the technique "knee on the floor".

The results concerning the activity profile of rink hockey can help coaches and practitioners to design specific training sessions according to the game demands.

However, the knowledge provided by the reviewed studies is still insufficient, highlighting the need for more research on this type of activity.

2.9. Comparative analysis

In the reviewed comparative studies researchers sought to explain player's activity and compared performances according to player position, match half, phase of the competition, age group and final result.

Players' positions

Rink hockey players are divided into three main field positions: goalkeepers, defenders/midfielders, and forwards (Vaz, 2011). Forwards perform significantly higher percentages of dribbling, with a significantly longer mean duration compared to other positions (Kingman & Dyson, 1997). They also make a significantly higher frequency of tackles, forehand flick shots, backhand flick shots and slide stops right (Kingman & Dyson, 1997b). However, it was not possible to calculate correlations between playing position and the intensity or direction of movement.

The results show the technical demands are different depending on the player's position on the field. This information is valuable information for coaches, which may help them to optimise training protocols and improve performance.

Match half

Throughout the game, it is possible to verify that in the first half, players perform more sprints, collect more loose balls (without being in possession) and execute slide stops left with more frequency than the slide stop right. However, in the second half of matches, there is more falling, and the game is played with a lower intensity (Kingman & Dyson, 1997b). Also, goalkeepers tend to be more effective in the first half compared to the second halves of the matches (Sousa et al., 2020). The decrement of physical performance in the second half of competition has been verified in different sports like football (Sarmento et al., 2014; Pratas, Volossovitch & Ferreira, 2012) or rugby (Duthie, Thornton, Delaney, McMahon, & Benton, 2017). We postulate that the decrements in physical performance observed in the second half

of rink hockey is due to fatigue; however, this requires further investigation. Reduced physical outputs may be a result of accumulated fatigue, pacing, or due to situational factors such as the scoreline or strategical-tactical adaptation by the two teams. Furthermore, a considerable change in the rules of the game occurred in 2009 (World Skate, 2018). One of the main changes involved a technical sanction punished with a direct free-hit each time a team accumulates 10 fouls or 5 additional team fouls. The application of this rule has resulted in more direct free-hits in the second halves of the matches. Knowing that rink hockey goalkeepers are less effective at saving direct free-hits (Sousa et al., 2020), the combination of reduction of physical capacity and the rule changes can contribute for the decline of effectiveness in the second halves of the matches.

Phase of the competition

During competitions, it is possible to detect changes in athlete performance. Bastos (2005) monitored the performance of the elite Portuguese national team during the 2003 World Championship, investigating mainly 1vs1 situations. The author concluded that the number of goals scored is higher in the qualifying phase when compared to the final phase of the competition (quarter-final, semi-final and final). Additionally, a low number of 1vs1 situations during organised attacks were observed in the second phase of the competition. This decline may be a result of more balanced matches, with successful 1vs1 situations being harder to achieve.

Age groups

In U-13, U-15 and U-17 age groups forward players perform a higher number of passes while in U-20 and seniors, defenders present greater OutDegree levels (identification of centrality level of a player when passing the ball) (Oliveira et al., 2015). These differences can be a consequence of the utilisation of the best young players as forwards in younger age groups allowing these players to have more ball possession and be more accurate in the offensive phase. In older age groups, the game is more tactical, and defenders assume a more significant prominence at the beginning of offensive possessions and also in maintaining ball possession (Oliveira et al., 2015).

The number of ball possessions per game increase as the athletes go up in age group (U-17 - 130; U-20 - 152; Seniors - 201) (Valente-dos-Santos, 2006). This may be a result of the short period of playing time in U-17 when compared with older age groups (U-17, 40 minutes; U-20, 50 minutes; seniors, 50 minutes). On the other hand, the difference between U-20 and seniors could be explained by the fact that in older age groups the intensity of the game is higher and players have a greater technical-tactical development. Valente-dos-Santos (2006) concluded that the percentage of organised attack is higher in U-20 when compared with U-17 teams and that 28% of ball possession ends with a shot on goal in both age groups. Counter-attack loses importance in older age groups, and fast-attacks gain greater relevance through the age groups (Valente-dos-Santos, 2006).

In the U-17 category, regained ball possessions are performed mainly through faults and defensive rebounds, while in the U-20 category most of the ball possessions start after a tackle, defensive recovery or a fault (Valente-dos-Santos, 2006). In most of the offensive actions, the defensive organisation overcomes the offensive organisation, the recovery of ball possession by the defensive team, most of the time, is performed after a tackle, a fault, or a shot at goal (Vaz, 2011; Valente-dos-Santos, 2006).

Game result

With regards to final game result, winning teams perform more fast-attacks and counter-attacks while losing teams have more ball possessions in organised attack (Rosa, 2006; Duque, 2004), which can reveal specific team strategies for the winning team. When winning, teams prefer to utilise counter-attacks, exploiting offensives mistakes to create situations of offensive superiority, while losing teams have to play in continuous attack, because the winning team adopt a more defensive posture. According to Ferreira (2003), there are no differences between winners and losers concerning ball possession; counter-attacks differentiate winning teams from losing teams. Better defensive teams have more chance of finishing attacks in numerical superiority. Furthermore, winning teams, besides having a more significant number of counter-attacks, also execute more shots at goal. These findings are in concordance with what happens in other team sports like football, where winning teams decrease their ball possession, suggesting they prefer to play using counter-attack or direct play (move the ball quickly to within scoring range) (Lago-Peñas & Dellal, 2010).

Losing teams spend a higher percentage of a half shooting backhand slap shots and have a significantly higher mean duration for dribbling, while winners fall more frequently, however for both, intensity and direction had no evident score effects (Kingman & Dyson, 1997b).

Home advantage

Home advantage is a widely accepted phenomenon and has been analysed in different sports contexts (Sánchez, García-Calvo, Leo, Pollard, & Gómez, 2009; Koning, 2005; Gómez et al., 2011; Arboix-Alió & Aguilera-Castells, 2019). It is an important factor to consider since allow understanding the effect that competing at home has on the result of sports competitions.

An analysis of the men's and women's Portuguese League provided evidence of greater home advantage in the men's league and also a significant number of goals scored when playing at home, both in men's and women's league (Arboix-Alió et al., 2020). The difference between genders in home advantage could be explained by some factors such as crowd effect and referee bias, territorial protection, and psychological aspects (Prieto, Gómez, & Pollard, 2013).

2.10. Limitations

Rink hockey has received little interest from the scientific community. To the best of our knowledge, this is the first systematic review of match analysis in rink hockey. Moreover, because of this lack of interest by the scientific community, much of the available literature might be published as grey literature, which makes it difficult to locate. Another limitation of this review is the fact that we only searched publications written in Portuguese and English. Perhaps if the search were extended to other languages (e.g., Spanish, Italian, French or German), more studies would emerge. Moreover, also extending the search to a higher number of electronic databases could have identified a higher number of publications.

Additionally, we would like to highlight the fact that this review only included five studies with a sample collected after the 2009 rule change (Oliveira, Clemente, & Martins, 2015; Arboix-Alió et al., 2020; Fernandez et al., 2020; Fernández, Varoet al.,

2020; Sousa et al., 2020). The main difference is that with the introduction of the 2009 rule change (World Skate, 2018) teams have 45 seconds to shoot at goal, whereas before 2009 there was no time limit. Furthermore, when a team makes 10 fouls they are penalised with a direct free-hit to the opposition, with a direct free-hit for every five fouls thereafter. This difference of in-game rule seems to have brought a different dynamic to the game. Nowadays, the game seems more fluid than what it was before 2009. However, there is a lack of studies that provide empirical data related to the differences caused by the rule change.

2.11. Conclusion

In the last few years, there has been an increase in the number of scientific publications in rink hockey (Vaz et al., 2016; Coelho-e-Silva et al., 2012; Valente-dos-Santos, Sherar, et al., 2013; Valente-dos-Santos, Coelho-e-Silva et al., 2013; Oliveira, Clemente, & Martins, 2015; Arboix-Alió et al., 2020; Fernandez et al., 2020; Fernández, Varo et al., 2020; Sousa et al., 2020). However, scientific publications in match analysis are scarce (Vaz et al., 2016; Mendo & Anguera, 2002; Kingman & Dyson, 1997, 1997b, 2001; Oliveira, Clemente, & Martins, 2015; Arboix-Alió et al., 2020; Fernandez et al., 2020; Fernández, Varo et al., 2020; Sousa et al., 2020). Nevertheless, most of the studies in match analysis are academic works (thesis) that never been published in international scientific journals, limiting access to the knowledge produced in these studies to the international scientific community as well as to rink hockey coaches.

From this review, it was possible to conclude that rink hockey is a fast game with low effectiveness where offensive actions tend to occur in periods below nine seconds and that teams prefer organised attacks to counter-attacks or fast-attacks. Rink hockey players perform, on average, 1004.7 actions per game spending on average 3.7 seconds on each action. Travelling with the ball and tackling are the most frequent actions.

When we considered ball possession it is possible to conclude that most of the offensive actions are performed in short periods and lead to a higher number of ball possessions per game (range: 55.6 to 105.5). Furthermore, the ball is regained mainly

by defensive actions and due to the laws of the game. Defensive and intermediate areas of the field are where teams preferentially start their offensive actions and teams prefer central areas near the goal to end these actions.

Rink hockey players' most frequent actions are ball conduction and tackling. Despite being considered a high-intensity game most of the actions are performed at a low-intensity (77% of the actions), and the majority of low-intensity actions are performed during the second half of matches. Moreover, winning teams perform more counter-attacks and fast-attacks in comparison with losing teams, who perform more organised attacks.

2.12. Future research

To create more knowledge about the transformations introduced to the game with the 2009 rule changes, more scientific research is required, particularly using newer technologies (e.g. GPS; match analysis software) and also new approaches to the study of tactical sequential events (e.g. networks; sequential patterns). Rink hockey has been growing since it was created as a team sport and the current challenge is to provide scientific knowledge that will allow extensive development, as seen in football (Sarmento, Marcelino et al., 2014) and basketball (Courel-Ibáñez et al., 2017).

Future studies should conduct a more detailed analysis of the activity profile of players and goalkeepers, the tactical and technical demands of the game according to situational variables (such as quality of opposition, match half, game location), the effectiveness of the offensive process, and the existence of patterns of play.

CHAPTER THREE: Study Two

3. Development and validation of an observational instrument tool for analysing the activity of rink hockey goalkeepers

Reference: Sousa, T., Sarmento, H., Harper, L. D., Valente-dos-Santos, J., & Vaz, V. (2018). "Development and validation of an observational instrument tool for analysing the activity of rink hockey goalkeepers." *Journal of Sport Pedagogy and Research*, 4(3), 16-26.

3.1. Abstract

The purpose of this paper was to develop and validate an observational instrument tool for observing and analysing the activity of rink hockey goalkeepers. The development and validation of the observational instrument were carried out based on five methodological stages.

The first and second phases were summarised in bibliographical research and an exploratory phase of rink hockey games observation. In the third and fourth stages, it was developed a questionnaire and the observational instrument, respectively. In the final stage, the instrument's reliability was tested. In this study, participated 64 coaches and 30 goalkeepers. Since the values of Kappa of intra- and inter-observer were higher than 0.70, the observational instrument was considered reliable to analyse the activity of rink hockey goalkeepers.

This observational instrument can allow coaches and performance analysts to analyse and quantify the performance of rink hockey goalkeepers.

Keywords: performance analysis; techniques; postures; roller hockey.

3.2. Introduction

Despite being played on five continents, rink hockey is lacking scientific research in comparison with other sports, which are widely studied and analysed like basketball (Delextrat & Martinez, 2014; Clemente, Martins, Kalamaras, & Mendes, 2015; Courel-Ibáñez, McRobert, Toro, & Vélez, 2017), football (Gama, Dias, Couceiro, Sousa, & Vaz, 2016; Rebelo, Brito, Seabra, Oliveira, & Krustrup, 2014; Sarmento et al., 2014; Sarmento, Anguera, Pereira, & Araújo, 2018; Gonçalves et al., 2017), futsal (Lapresa, Alvarez, Arana, Garzón, & Caballero, 2013; Sarmento et al., 2016; Serrano, Shahidian, Sampaio, & Leite, 2013), rugby (Duthie, Thornton, Delaney, McMahon, & Benton, 2017; Kennett, Kempton, & Coutts, 2012) and volleyball (Almujahed, Ongor, Tigmo, & Sagoo, 2013; Palao, Manzanares, & Ortega, 2015; Silva, Marcelino, Lacerda, & Vicente, 2016). The lack of systematic and consistent theoretical and practical investigations of rink hockey make it challenging to have a real, accurate and undistorted view of the game (Gayo, 2000). Despite this lack of systematic and consistent theoretical and practical investigations, past research has been developed in topics such as: (1) patterns of play (Mendo, 2002; Oliveira, Clemente, & Martins, 2015; Vaz et al., 2016); (2) morphological and physiological demands (Hoppe et al., 2015; Valente-dos-Santos et al., 2014; Valente-dos-Santos et al., 2013; Yagüe, Del Valle, Egocheaga, Linnamo, & Fernández, 2013); (3) talent identification (Coelho-e-Silva et al., 2012); (4) dietary intake and body composition (Silva & Silva, 2017) and; (5) biomechanics (Vaz, Ramos, Abrantes, & Melo, 2011).

Rink hockey goalkeeping is an unusual exercise involving quick reactions, flexibility, muscular strength and stamina, all of which are constrained by the weight and size of the protective padding and the position the goalkeeper must adopt (Kingman & Dyson, 2001). Due to the enormous speed of the game and the reduced number of field players, the rink hockey goalkeeper plays an important role in the game, with much of the responsibility of leading a team to success (Trabal, 2016).

Although playing an important role, the research devoted to this specific player is still scarce. In other sports the study of the goalkeepers gained higher relevance when compared with rink hockey: (1) football (Gonçalves, Severino, Silva, & Figueiredo, 2011; Lago-Peñas, Casais, Dellal, Rey, & Domínguez, 2011; Rebelo-Gonçalves,

Coelho-e-Silva, Severino, Tessitore, & Figueiredo, 2015; Rusu, Stoica, & Burns, 2011; Ziv & Lidor, 2011; Park, Choi, Bang, & Park, 2016); (2) ice hockey (Frayne & Dickey, 2017; Sigmund et al., 2016; Vescovi, Murray, & Vanheest, 2006); handball (Chaouachi et al., 2009; Justin, Vuleta, Pori, Kaitna, & Pori, 2013; Rousanoglou, Noutsos, & Bayios, 2014); (3) field hockey (Malan, Dawson, Goodman, & Peeling, 2010); (4) futsal (Vicente-Vila & Lago-Peñas, 2016), and; (5) water polo (Kondrič, Uljević, Gabrilo, Kontić, & Sekulić, 2012).

As far as scientific publications are concerned, the only published articles exclusively on the rink hockey goalkeeper were written by Mori (1991), Kingman and Dyson (2001), and Trabal (2016). Mori wrote about the specificity of the physical training of rink hockey goalkeepers because the goalkeeping actions are very specifics and very different from the other players (Mori, 1991). Kingman and Dyson analysed the distribution of the shots at goal as well as of the movement of the goalkeepers (Kingman & Dyson, 2001), while Trabal (2016) conducted an ethnographic study in which the primary objective was to understand how the hockey community values the goalkeeper, as well as to understand how the fans evaluate and analyse the goalkeepers' performance.

Taking into account the importance for coaches and practitioners and the scarcity of scientific knowledge concerning this specific functional position in rink hockey this study aimed to develop an observational instrument tool to analyse the activity of rink hockey goalkeepers.

3.3. Methods

Procedures

The development of an observational instrument to analyse the activity of rink hockey goalkeepers was carried out based on the following methodological steps: (1) bibliographical research, with the purpose to carry out a rigorous survey of scientific publications that studied the rink hockey goalkeepers and respective techniques; (2) an exploratory phase with several sessions of observation of rink hockey games (several games from the European Championships of 2014 and 2016 and from World Championships of 2013 and 2015), taking into account the objectives of the work and

the defined criteria; (3) development of a questionnaire to validate a nomenclature for the techniques of the rink hockey goalkeepers; (4) presentation of the list of criteria, behaviours and rink hockey techniques to a panel of 5 experts for content validation. The experts met one of this conditions: i) were rink hockey coaches; ii) were researchers with experience in rink hockey match analysis; iii) were rink hockey players, and; (5) to ensure the stability of observations and the reliability of data collection it was analysed the data quality intra- and inter-observer agreement, which was verified through the kappa reliability test. To carry out intra-observer reliability test were selected two Portuguese national team games from the 2016 European Championship to be encoded twice. The observation was made with an interval of two weeks to minimise the difference between ratings. To carry out the analysis of the inter-observer reliability test, an observer was used who, in addition to his extensive experience of training and practice of the sport, is also a researcher in this area of knowledge. In this sense, the observer underwent a training process to optimise his observational performance. The observer performed the analysis of the two games previously described to make possible the determination of the inter-observer reliability test.

Questionnaire

The questionnaire was structured as follows: (1) an initial part where a request for cooperation was made in completing and explaining the reason for the application of the questionnaire; (2) a second part, where a brief glossary was made on the positions used by rink hockey goalkeepers; (3) a third party, based on the positions and techniques of the rink hockey goalkeepers available on the existing literature, whose objective was to collect the opinion of the coaches about the nomenclature to be used. For this purpose, photographs of the techniques with a brief description were presented, and; (4) a fourth part, aimed at collecting personal data that would characterise the respondents from the point of view of age, gender, sports experience as an athlete and as a coach.

The questionnaire was submitted to a validation process by expert opinion (10 experts). The following criteria were defined for the definition of experts, which should be observed similarly: (1) hold at least one of the different coach level (I, II and III), and; (2) have experience as a coach. Almost all of the experts held an

academic degree in Sports Sciences: (1) two were University Professors, being that they had the degree of PhD. or MSc. in Sports Science; (2) three where Master's degree in Sports Sciences; (3) four had a degree in Sports Science, and; (4) one expert had no academic formation.

To validate the name of the rink hockey goalkeepers' techniques, a cut-off value of > 50% was defined, that is, at least half of the interviewed coaches (32) would have to agree on the name of the technique in question. Whenever a technique did not reach the cut off value, a group of 30 rink hockey goalkeepers filled the same questionnaire, to, untie between the two most selected names by the coaches (the responses of the goalkeepers were conditioned to only two options of an answer).

Observational instrument

Collective sports, in general, are characterised by an enormous diversity of situations that can be systematically observed, which means that standardised instruments should be replaced by specific instruments, built *ad hoc*, according to the specific reality that one wishes to study (Anguera, Blanco, Losada, & Hernández, 2000).

For the development and validation of the observational instrument, we followed a series of steps, always based on the knowledge of the game, as well as experience as a goalkeeper and coach of rink hockey and also based on the available literature. In this way, based on the defined objectives: (1) it was delimited the part of the reality that we were interested in observing; (2) it was determined the main criteria be analysed, and; (3) finally, through an exploratory phase based on experience as a coach and goalkeeper, as well as based on the literature available, was created a list of conducts for each criterion in analysis.

The criteria were chosen according to the objectives of our study, allowing contextualising the offensive action, as well as the actions of the goalkeepers and also taking into account the logic of the game, from the recovery of possession of the ball to the offensive development and its completion:

- Criteria 1 – Offensive process: context;
- Criteria 2 – Beginning of the offensive process;

- Criteria 3 – Development of the offensive process;
- Criteria 4 – End of the offensive process.

With the intention of register and coding the observed conducts, a spread sheet was written in Microsoft Excel®, with VBA macros (Visual Basic for Application), that was separated in 3 user forms: (1) the first user form, describes the context in which the game is played (Table 3.1) and the beginning of the offensive process (Table 3.2); (2) the second, analysis the development of the offensive process (Table 3.3), and; (3) the third, describes the end of the offensive process (Table 3.4).

To contextualise the game situation, it was identified the team in analysis, the half of the game in which the offensive process is taking place, the momentary result and also the numerical relationship between the team in the offensive process and the team in the defensive process (Table 3.1).

Table 3.1 Contextualization of the beginning of the offensive process.

Offensive Process: Context		
Category	**Code**	**Description**
Team	A or B	Identification of the observed team
Half: sub-criterion that identifies the part of the game in which the offensive process is taking place.		
1ª half	1p	Game time from the referee's whistle to the beginning of the first half to the whistle of the whistle to the end of this half, according to the laws of the game.
2ª half	2p	Game time from the referee's whistle to the beginning of the second half to the whistle of the whistle to the end of this half, according to the laws of the game.
Overtime	Prl	Game time from the referee's whistle to the beginning of the first half of the overtime to the whistle of the referee to the end of the overtime, following the laws of the game.

Table 3.1 Contextualization of the beginning of the offensive process (cont.).

Momentary result: sub-criterion related to the number of goals scored by the team observed and by the opposing team in the momentary game situation.		
A Win by more than one goal	G2	The observed team has at least two more goals scored than the opponent.
A win by a goal	G1	The observed team has one more goal scored than the opponent.
A Tie	G0	The observed team has the same number of goals as the opponent.
Lose by a goal	P1	The observed team has one less goal scored than the opponent.
Loses by more than one goal	P2	The observed team has at least less than two goals scored than the opponent.
Numerical relationship: sub-criterion related to the number of players of the observed team and the opposing team at the observed moment.		
Numerical superiority	SN	The observed team has a numerical advantage on the field by the suspension of one or two opponents.
Numerical equality	IN	The observed team is numerically equal to the opponent.
Numerical inferiority	Ifn	The observed team has numerical inferiority on the field by the suspension of one or two players.

After contextualising and identifying the team in possession and the circumstances in which the offensive process unfolds it will be described the way the team regained ball possession (Table 3.2).

Table 3.2 Description of the beginning of the offensive process.

The beginning of the offensive process (IPO)		
Category	**Code**	**Description**
The beginning of the game	Ij	The offensive process begins with the whistle of the referee to start the game, part 2 of the game or extra time.
Interception	Ipi	The offensive process begins after an interception of a pass or shot without interruption of the game.
Disarm	Ipd	The offensive process begins after a disarming, without interruption of the game.
Goalkeeper action	Ipgr	The offensive process begins after recovery of the ball after a save.

Table 3.2 Description of the beginning of the offensive process (cont.).

The beginning of the offensive process (IPO)		
Category	**Code**	**Description**
Regulatory disruption of the game in favour	Ipera	The offensive process begins after a regulatory interruption of the game.
Ball recovery	IpRB	The offensive process starts when the opponent makes a wrong pass to a zone of the field where there is no element of his team or after a poorly directed shot.
The goal of the opposing team	Ipera	The offensive process starts after a goal conceded.
Direct free-hit	LD	The offensive process begins with a direct free-hit.
Penalty	P	The offensive process begins with a penalty.

In the description of the development of the offensive process, it was taking into account the interactions and actions taken by the players in the different zones of the field (Table 3.3).

Table 3.3 Description of the development of the offensive process

Development of the offensive process		
Category	**Code**	**Description**
Zone of the field	1D; 1C; 1E; 2D; 2C; 2E; 3D; 3C; 3E; 4D; 4C; 4E; 5D; 5C; 5E; 6D; 6C; 6E;	The rink hockey field is divided into 3 corridors (left, centre and right) 6 areas (1; 2; 3; 4; 5; 6) and 18 zones, the defensive zone corresponding to areas 1 and 2, areas 3 and 4 are the intermediate areas of the field and 5 and 6 are considered definition areas.
Pass	Pse	Action in which the player of the team in the offensive process makes a pass.
Reception	Rcp	Action in which the player of the team in the offensive process makes the reception of a pass made by a player of the same team.
Shot	Rmt	Action in which the player of the team in the offensive process shot at the goal.

In the description of the end of the offensive process is taken into account the actions taken by players and goalkeepers after the offensive process (Table 3.4).

Table 3.4 Description of the end of the offensive process.

End of the offensive process (FPO)		
Category	**Code**	**Description**
Final Actions	Def	When the goalkeeper carries out an action that prevents the ball from entering the goal.
	Golo	When the offensive process ends with a goal in favour duly validated by the referee.
Goalkeeper	A or B	Identification of the observed goalkeeper.
Goal	SD; SC; SE; MD; MC; ME; BD; BC; BE;	Zones of the goal where the shots are directed; The first letter corresponds to the height of the goal (S - upper, M - medium, B - low) and the second letter corresponds to the side of the goal (D - right, C - centre, E - left).
Segments	Cba	Corresponds to the goalkeeper's head.
	Tco	Corresponds to the goalkeeper's upper body.
	MSd	Corresponds to the right superior member of the goalkeeper.
	MSe	Corresponds to the left superior member of the goalkeeper.
	MId	Corresponds to the right inferior member of the goalkeeper.
	MIe	Corresponds to the left inferior member of the goalkeeper.
	Stk	Corresponds to the goalkeeper's stick.
Techniques	JCh	Knee on the floor - the goalkeeper, has one leg flexed, supporting the weight of the body, and the other in lateral extension or folded; the arm of the stick next to the body, or slightly away; the free glove raised approximately at head height and the side of the shoulder; body straight, and; head oriented to the ball.
	Mch	Fleck – legs semi-bent and overlapping each other; the stick arm next to the body and supporting the weight of the body; free glove raised approximately at heads height and the side of the shoulder; body straight, and; head oriented to the ball.

Table 3.4 Description of the end of the offensive process (cont.).

End of the offensive process (FPO)		
Category	**Code**	**Description**
	Ccr	Squatting – the goalkeeper has the weight of the body supported by one or two brakes and front wheels of the skates; stick glove in contact with the ground or slightly raised, stick in front of the skates; free glove lifted approximately at head height and the side of the shoulder; body straight, and; head oriented to the ball.
	Lqe	V Position - the goalkeeper has his legs "V" position; the stick arm next to the body and supporting the weight of the body; the free glove raised approximately at the head height and the side of the shoulder; body straight, and; head oriented to the ball.
	Epg	Spatula - the leg of the side of the stick folded, while the other leg in extension; stick placed in front of the leg in extension; free glove at shoulder height; body slightly sloping over the leg in extension, and; head oriented to the ball.
	QLa	Side fall - legs extended or slightly apart; the arm of the stick with the elbow in contact with the ground or full extension; the arm of the free hand folded with the glove placed next to the body or in total extension; trunk slightly raised concerning the ground, and; head oriented to the ball.
	Prl	"Seated" - legs bent with the shin guards facing the ball zone and parallel to the goal line; the arm of the stick folded and placed over the shin guard; free glove raised approximately at head height; body straight, and; head oriented to the ball.

Validation of the observational instrument

Due to the importance that rink hockey goalkeepers have on a team's success and since there is not an instrument that could analyse their activity in competition, this study aimed to develop an observational instrument tool that could help coaches and researcher to understand rink hockey goalkeepers' performance better.

Being the reproduction of a study one of the main characteristics of scientific research, to circumvent the influence of this individual character, ensuring the possibility of replicating the study, besides describing the methodological steps adopted in the elaboration of the observational instrument, it is necessary to ensure that he even allows you to observe what you really want to observe (Sarmento, 2012). Therefore, the validation of the observational instrument is one of the methodological steps to be followed, to respect the validity of the content and the construct.

Ensuring high reliability in the observations is an indispensable condition for further analysis of the data, thus ensuring the existence of a small number of errors and thus ensuring stability and consistency in the assessment of the characteristics observed (Anguera et al., 2003).

Data quality control was carried out using coefficients of agreement, in particular, the reliability index of kappa. The kappa reliability index, or Cohen's kappa index, suggests that for reliability to exist between observations, the kappa value should be higher than 0.70, and the higher the value approaches, the higher the degree of intra- and inter- observations (O'Donoghue, 2013).

Two games were analysed (Portugal *vs* Italy and Portugal *vs* Switzerland), with inter- and intra-observation being two weeks apart from the first observation (Tabachnick & Fidell, 2007). To determine the value of kappa we used the IBM SPSS® Statistics 22 software. To carry out the analysis of the inter-observer agreement index, an observer was used who had extensive experience of training and practice of the sport. In this sense, the observer underwent a training process for two weeks, to optimise his observational performance. At the end of this period and after clarifying several doubts and questions related to the process, there was a coherence and approximation of the results found in the analysis of the offensive sequences. In this way, the observer performed the analysis of the two games previously described to make possible the determination of the inter-observer agreement index.

The observational instrument revealed high values of intra- and inter-observer reliability, since the values obtained, for all categories, were higher than 0.70 (Table 3.5).

Table 3.5 Analysis of data quality.

	1st Game		2sd Game	
	Intra-observer	**Inter-observer**	**Intra-observer**	**Inter-observer**
Zone of the Goal	.914	.893	.888	.859
Segment	.879	.828	.935	.935
Technique	.893	.856	.965	.931
Pass	.883	.792	.953	.842
Reception	.860	.833	.916	.799
Shot	.900	.778	.919	.870

3.4. Results

Portuguese rink hockey coaches filled out sixty-four questionnaires. The average age of the coaches was 40.5 (± 8.5 years) being that the oldest coach enquired had 61 years old and the youngest 22. Also, rink hockey goalkeepers filled out thirty questionnaires to clarify the names of the techniques that coaches could not get into an agreement. The average age of the goalkeepers was 27.4 (± 5.0 years) the youngest was 20 years old and the oldest 38 years (Table 3.6).

Table 3.6 Distribution of coaches and goalkeepers by age group.

Age group	**Frequency(n)**		**Percentage (%)**	
	Coaches	**Goalkeepers**	**Coaches**	**Goalkeeper**
< 31 years	7	24	10.9	80.0
31 a 40 years	19	6	29.7	20.0
41 a 50 years	15		23.4	
> 50 years	7		10.9	
Did not answer	16		25.0	
Total	**64**	**30**	**100.0**	**100.0**

56.3% of the total coaches surveyed were level II coach, and 25.0% was level I and only 18.7% of the coaches were level III.

Almost all of the interviewed coaches were or was (at the time of data collection) rink hockey players (93.75%), and only 9 (14.1%) has been international players with an

average of 28.6 (± 46.9) games played for the national team. 11.5 (± 7.5 years) were the average years of experience as coaches from the sample.

Goalkeepers' techniques

Figure 3.1 shows the seven techniques that were presented to coaches and goalkeepers, so they could choose the name that they considered most appropriate for each technique, the definition of the techniques and the respective nomenclature is presented in Table 3.7.

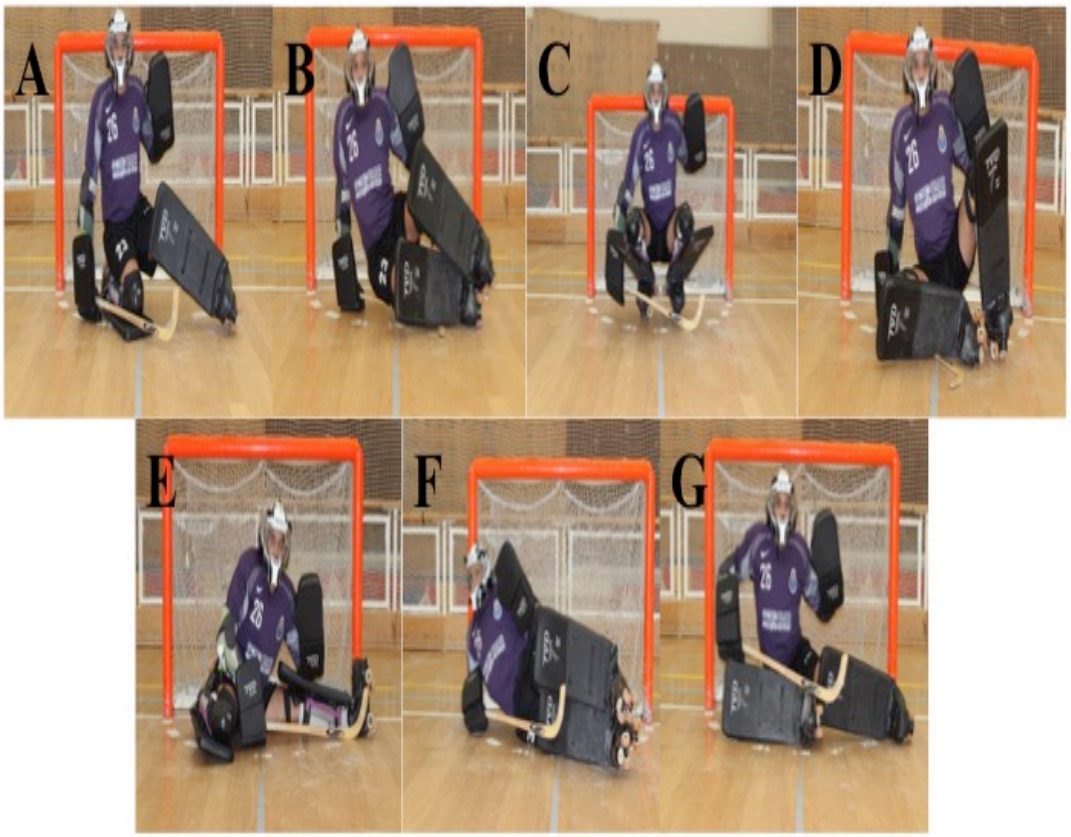

Figure 3.1 Principal techniques of rink hockey goalkeepers.

The techniques A (76.5% - knee on the floor), C (68.7% - squatting) and F (51.5% - side fall) were the only techniques that had values higher than the value of cut (> 50%) (Table 3.7).

Table 3.7 Definition of nomenclature of goalkeeper techniques by rink hockey coaches.

Techniques	Nomenclature				Other	Did not answer
A	Knee on the floor 76.5%	T Position 7.8%	Lateral side 3.1%	Sitting on the skate 7.8%	4.7%	0%
B	Screen 7.8%	Fleck 45.3%	Parallel 28.1%	Wall 10.9%	4.7%	3.1%
C	Squatting 68.7%	On wheels 21.8%	Bent legs 1.5%	Crouching 3.1%	4.6%	0%
D	Half fleck 18.7%	V Position 46.8%	Fan 21.8%	Stick support 9.3%	3.1%	0%
E	Scissors 17.1%	Spatula 35.9%	Barrister's position 32.8%	Seated 10.9%	1.5%	1.5%
F	Side fall 51.5%	Fleck 17.1%	Side Stretch 17.1%	Lying 10.9	1.5%	1.5%
G	Parallel 34.3%	Shin Guards on the Floor 20.3%	Seated 23.4%	L Position 18.7%	3.1%	0%

The results showed that goalkeepers had no doubts about the most appropriate name for the techniques presented. Using the same value of cut (> 50%) used for the answers of the coaches, it was possible to conclude that the technique B should be called “fleck”, the D “v position”, the E “spatula” and G “seated” (Table 3.8).

Table 3.8 Definition of nomenclature of goalkeeper techniques by rink hockey goalkeepers.

Techniques	Nomenclature	
B	Fleck 70.0%	Parallel 30.0%
D	V position 60.0%	Fan 40.0%
E	Spatula 86.7%	Barrister's position 13.3%
G	Parallel 26,7%	Seated 73.3%

Goalkeepers' positions

Based on Figure 3.1 coaches were query about the position adopted by the goalkeepers (Table 3.9).

Table 3.9 Positions adopted by rink hockey goalkeepers.

Positions	Basic	Expectation	Optimum	Emergency	Did not Answer
A	76.5%	14.0%	9.4%	0.0%	0.0%
B	4.7%	31.3%	35.9%	25.0%	3.1%
C	60.9%	25.0%	10.9%	1.5%	1.5%
D	12.5%	42.1%	25.0%	18.7%	1.5%
E	4.6%	9.3%	15.6%	68.7%	1.5%
F	1.5%	3.1%	7.8%	84.3%	3.1%
G	1.5%	26.5%	26.5%	43.7%	1.5%

Coaches considered the techniques A (knee on the floor) and C (squatting) with 76.5% and 60.9% respectively as "basic position" for goalkeepers. Also considered techniques E (spatula) and F (side fall) as "emergency position" 68.7% and 84.3% respectively. For the technique B (fleck) coaches considered that this technique could be considered as a position of "expectation" (31.3%), "optimum" (35.9%) and "emergency" (25.0%). Coaches considered technique D (v position) as an "expectation position" (42.1%), but a large proportion of the coaches also considered as an "optimum position" (25.0%) and as an "emergency position" (18.7%). For the

technique G (seated) most of the coaches divided their opinion between “expectation” and “optimum position” (26.5% each), but the position that met the greater consensus from the coaches was as “emergency position” (43.7%).

3.5. Discussion

The rink hockey goalkeeper has an important role in a team's success. Taking into account that his performance could be the difference between winning and losing, this study aimed to develop an observational instrument tool that could help coaches to analyse the activity of rink hockey goalkeepers.

Each sport has its specificity, concerning the required motor skills, which imply the realisation of specific positions and movements (Paillard, 2017). For the rink hockey goalkeepers, the position serves to carry out defence actions with the highest efficiency and the least expenditure of energy possible (Porta & Mori, 1987). The goalkeepers' position can be classified into: (1) "basic position" – attitude taken by the goalkeeper, from which can carry out defensive actions quickly and effectively. It can be adopted in various game situations, taking into account the positioning of the ball, for this, the goalkeeper only needs to adjust the position of some of the body segments taking into account the occupation of spaces in the goal; (2) "expectation position" – attitude adopted by the goalkeeper at times when the team owns the ball in areas away from the goal. The goalkeeper takes a more relaxed position, but that allows him to recover to the starting position quickly; (3) "optimum position" – posture adopted by the goalkeeper that allows to carry out a save with efficiency and economy of effort; (4) "emergency position" – a position adopted by the goalkeeper whenever he needs to make a defence after an action (e.g., displacement, save) (Caramés, 1995).

The results of our query, to coaches and goalkeepers, allowed us to create a nomenclature for the different techniques of rink hockey goalkeepers. Seven techniques were presented to coaches (see Figure 3.1), so they could give their opinion about the name most suitable and also about the type of position that those techniques represented.

The contribution of these experts (coaches and goalkeepers) had an essential contribution to the development of the observational instrument allowing us to develop a nomenclature for the techniques of rink hockey goalkeepers.

The result of this query was: (1) technique A – “knee on the floor”; (2) technique B – “fleck”; (3) technique C – “squatting”; (4) technique D – “v position”; (5) technique E – “spatula”; (6) technique F – “side fall”, and; (7) technique G – “seated” (see Figure 3.1).

In the questionnaire, coaches were proposed to classify techniques according to the type of position adopted. It was possible to conclude that for coaches, "knee on the floor" and "squatting" corresponds to a "basic position", or in other words, an attitude adopted by the goalkeeper, from which he can carry out defensive actions quickly and effectively. "Spatula" and "side fall" correspond to an "emergency position", that is, the posture adopted by the goalkeeper whenever he needs to make a defence after an action (e.g., move, defence). In the other techniques, there is not such a high consensus by the coaches, and this may be associated with the fact that many of the techniques presented could be used in different game situations. Regarding "fleck", coaches considered that this technique could be defined as a "position of expectation", also as an "optimum position" and "emergency position". Concerning the fact that coaches identified this position as an "optimal position" (a position taken by the goalkeeper that allows the defensive action to be carried out efficiently and effortlessly) and an "emergency position" may be associated with being a position that allows the goalkeeper occupies a large area of the goal. It is not very understandable why coaches consider this technique a "position of expectation". By definition, a "position of expectation" corresponds to the attitude adopted by the goalkeeper whenever his team his in possession of the ball.

Finally, and after been tested by two observers (intra- and inter-observer reliability), it was possible to conclude that this observational instrument is trustworthy to observe the activity and quantify the actions performed by the rink hockey goalkeepers. Therefore, coaches and performance analysts can use the instrument in rink hockey for assessment and performance analysis purposes.

One of the limitations that could be pointed to this observational instrument is that it only analyses the team with the possession of the ball, the actions of the player with the ball and the action of the opposing goalkeeper. The player's that are participating in the defensive process was not considered. Therefore, future studies should take into consideration not only the team in possession of the ball but also the team in the defensive process. It would also be interesting to analyse the movement of the players and goalkeepers off the ball.

3.6. Conclusions

This observational instrument is valid for analyse goalkeepers' activity in rink hockey allowing understand the most common techniques used by the goalkeepers. It will allow coaches and researchers to differentiate technical differences between goalkeepers, between winning and losing teams and what will help to understand what differentiates international goalkeepers from the other goalkeepers.

This observational instrument could be used in research as in competition to analyse to assess rink hockey goalkeepers' performance. The data collected by this instrument provides information to rink hockey coaches that could be useful in the improvement of goalkeepers' techniques.

CHAPTER FOUR: Study Three

4. The influence of opponents' offensive play on the performance of professional rink hockey goalkeepers

Reference: Sousa, T., Sarmento, H., Marques, A., Field, A., & Vaz, V. (2020). "The influence of opponents' offensive play on the performance of professional rink hockey goalkeepers." *International Journal of Performance Analysis in Sport, 20(1), 53-63.*

4.1. Abstract

The purpose of this study was to analyse the performance of professional rink hockey goalkeepers and ascertain whether this is influenced by the opposition's offensive play.

A sample of 40 matches, including 1713 shots on goal from the Portuguese First Division (2016/2017) was analysed using Chi-square and logistic regression analysis.

The results suggest that goalkeepers are more effective in the 1st half versus the 2nd half (odds ratio [OR] = 1.39; 95% CI: 1.06-1.82; $p = 0.017$) of matches. Goalkeeping performance was also lower in the direct free-hits (OR = 0.22; 95% CI: 0.13-0.38; $p < 0.001$) and penalties (OR = 0.12; 95% CI: 0.06-0.22; $p < 0.001$), when compared with indirect free-hits. The technique most used by rink hockey goalkeepers to save shots at goal is the "knee on the floor". Observations demonstrate that when attacks commence in the oppositions defensive area, teams are 55% more likely to score and shots at the upper zones of the goal have a higher probability of being successful.

These findings could assist coaches and researchers in understanding current goalkeeping performance in relation to offensive patterns of play in rink hockey.

Keywords: roller hockey; match analysis; patterns of play; notational analysis; goalkeeper techniques.

4.2. Introduction

Rink hockey (otherwise known as roller or hardball hockey) is a physiologically demanding, intermittent team sport that requires balance, speed, coordination and explosive strength (Yagüe, Del Valle, Egocheaga, Linnamo, & Fernández, 2013). The sport has seen an exponential increase in published scientific literature over the past 25 years. These studies have included, among others, ball possession (Vaz, 2011; Mendo & Anguera, 2002), types of attack (Vaz et al., 2016), finishing actions (Vaz, 2011), specific characteristics according to players functional field positions (Kingman & Dyson, 1997; 1997b), age group (Oliveira, Clemente, & Martins, 2015; Santos, 2006), situational variables (Kingman & Dyson, 1997b), phase of the competition (Bastos, 2005), and match result (Kingman & Dyson, 1997b). However, these investigations have focused mainly on outfield players with a notable lack of attention afforded to the performance of rink hockey goalkeepers.

The goalkeeper is typically the last line of defence for rink hockey teams with a role focused on reducing goals conceded. This specialised position requires quick reactions, mobility, endurance and strength, whilst restricted by protective gear and the crouched position they are required to adopt (Sousa et al., 2018). To date, studies have investigated the movements of rink hockey goalkeepers concerning the position of shots at the goal using match footage from teams in the English National Premier League (Kingman & Dyson, 2001). However, it should be considered that this study analysed a small number of matches (6) and a sizeable change to the rule set in 2009 was employed, which may potentially limit the applicability of the aforementioned research. Therefore, further research is warranted using larger sample samples with novel perspectives on the unique demands (i.e., movement and skilled/technical actions) of this bespoke position.

Rink hockey is anecdotally renowned for being predominantly offensive in nature as it is purported that players perform 408-422 displacements during a match (Tantiña, Vidal, & López, 2014) being that most of the offensive actions are performed in short periods, which leads to a high number of ball possessions per game (range: 55.6 to 105.5) (Brázio, 2006; Duque, 2004; Rosa, 2006; Vaz, 2011). Almost half of these offensive actions result in a goal attempt, yet only 3% of these ensue in goals scored

(Ferreira, 2003). Rink hockey, like futsal (Agras et al., 2016) is a sport of finishing actions. However, the extent to which opponents' offensive play influences the effectiveness of the performance of rink hockey goalkeepers is somewhat unknown. Accordingly, it may be important to consider goalkeeping actions concerning the opponents attacking play. Furthermore, a validated observational instrument has been developed for analysing the activity of rink hockey goalkeepers (Sousa et al., 2018). Therefore, the aim of this study was twofold: 1) to investigate the activity and performance of rink hockey goalkeepers; 2) to assess whether the oppositions attacking play has any relationship with goalkeeping performance.

4.3. Methods

Procedures

A total of 40 games, including 1713 shots at goal from the 2016/2017 season in the Portuguese Rink Hockey First Division were analysed. The sample included matches from 13 out of 14 teams that participated in the Portuguese League (one was excluded from the competition by the Portuguese Roller Sports Federation). Of the 13 teams analysed, we obtained footage for ~ 6 games from each team.

Data coding system

Data were analysed using a specific notational analysis system developed and validated by Sousa et al., (2018). The variables were divided into four categories: (1) context of attacking play; (2) beginning of attacking play; (3) development of attacking play, and (4) end of attacking play (Table 4.1). For the characterisation of attacking play, a validated rink hockey field was utilised Gayo (2000). The field is divided into 18 areas, which comprised of 3 corridors and 6 sectors (Figure 4.1) (Vaz et al., 2016).

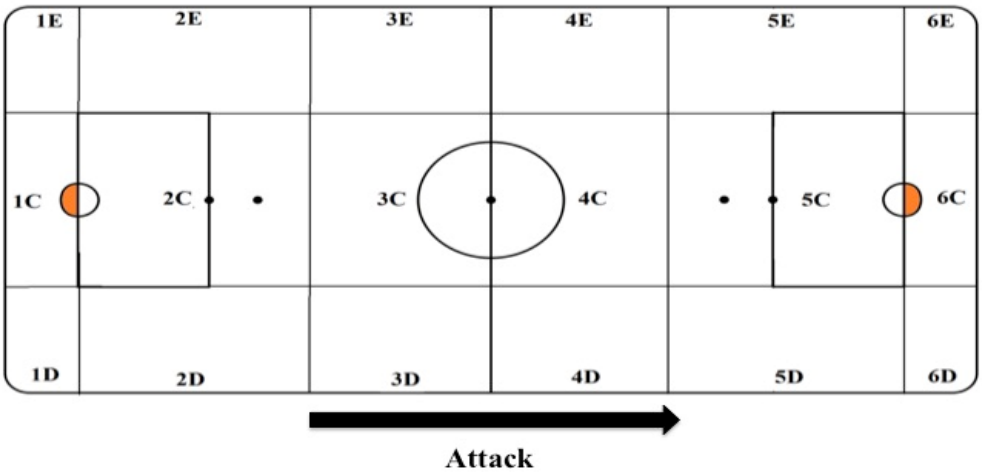

Figure 4.1 Rink hockey field playing zones. Defensive areas: zones 1 and 2; intermediate areas: zones 3 and 4; offensive areas: zones 5 and 6 (Vaz et al., 2016).

Table 4.1 Descriptions of variables and definitions of the categories used in the team match performance analysis (context of attacking play).

Variables and categories
Context of attacking play
Half
1st Half – 00:01 - 25:00 minutes.
2nd Half – 25:01 – 50:00 minutes.
Start of the offensive process
After a break in play:
Break-in play – attacking play begins after a break in play.
A goal from the opposing team – attacking play starts after a goal is conceded.
Direct free-hit – attacking play starts with a direct free-hit.
Penalty – attacking play restarts with a penalty.
Dynamic movement:
Interception – attacking play is started after an interception of a pass or shot, is made without interruption of the game.
Disarm – attacking play commences after a disarming of an opponent without interruption of the game.
Goalkeeper action – attacking play begins after recovery of the ball or after a save from the goalkeeper.
Ball recovery – the attacking play starts when the opponent makes a misplaced pass to a zone of the field where there is no element of his team or after a poorly directed shot.

Table 4.1 Descriptions of variables and definitions of the categories used in the team match performance analysis (context of attacking play) (cont.).

Variables and categories
Development of the offensive process
Area whereby attacking play commences – area of the field where teams regained ball possession.
Area of the last pass – the area of the field where players made the last interaction (pass).
Shooting area – the area of the field where teams finished their offensive action with a shot at goal.
Zone of the field – the rink hockey field is divided into 3 corridors (left, centre and right), 6 areas (1, 2, 3, 4, 5, and 6), and 18 zones, the defensive area corresponding to areas 1 and 2, areas 3 and 4 are the intermediate areas of the field and 5 and 6 are considered definition areas.
End of attacking play
Zones of the goal – zones of the goal where the shots are directed.
Techniques – rink hockey goalkeepers' technique used to save a goal attempt.

For intra-observer reliability, the lead investigator compared the same observations of two games (which included 96 actions), on two separate occasions, two weeks apart from one another (Tabachnick & Fidell, 2007). Concerning inter-observer reliability, an additional experienced researcher in this field was trained to use this specific observational instrument tool. After this process, he independently observed the same two games. Cohen's *kappa* index (Robinson & O'Donoghue, 2007) was calculated to analyse the results. This instrument revealed high intra-observer and inter-observer reliability since values obtained for all categories were higher than 0.70 (Table 4.2).

Table 4.2 Kappa values for intra-observer and inter-observer reliability.

	Intra-observer		**Inter-observer**	
Variable	**Kappa**	**CI (95%)**	**Kappa**	**CI (95%)**
Start of the offensive process	0.96	0.95-0.97	0.88	0.85-0.92
Development of the offensive process	0.87	0.85-0.88	0.93	0.92-0.93
End of the offensive process	0.92	0.89-0.97	0.89	0.83-0.93

Statistical analysis

All analyses were conducted using the software IBM SPSS, version 22.0. A Chi-square test was performed to determine whether each independent variable (i.e., Half; Match Status; Final result; Start of attacking play; Development of attacking play; Zones of the goal, and; Techniques) was associated with the final action (i.e., save or goal). A logistic regression analysis, using stepwise backward selection (Kleinbaum & Klein, 2010), was performed to examine the relationship between goalkeeper's effectiveness, and "Half", "Match Status" and "Final result". This statistical test was also employed to assess the relationship between the goalkeeper's effectiveness, and the different aspects of attacking play. Alpha was set at <0.05 prior to analyses.

4.4. Results

Differences in variables such as "Half", "Match Status" and "Final result" were found to affect the goalkeepers' effectiveness according to opponents attacking play (Table 4.3).

Goalkeepers tend to be more successful (i.e., more likely to save shots) in the 1st half rather than in the 2nd half 1.39 (OR) (95% confidence interval [CI]: 1.06-1.82; p = 0.017). On the other hand, when the observed team had at least two or more goals scored than their opponent, the effectiveness of the opposition goalkeeper dropped by 45% when compared with when the match is tied (odds ratio [OR] = 0.55; 95% CI: 0.37-0.81; p = 0.003). When a team loses, the probability of the opponent goalkeeper making a save is 2.26 times higher than when the team wins the match (95% CI: 1.61-3.15; p < 0.001). Additionally, when the two teams draw, the probability of the goalkeeper saving a shot is 1.62 times higher than when one of the teams win the contest (95% CI: 1.18-2.22; p = 0.003).

Table 4.3 Differences in goalkeepers' effectiveness according to the context of the offensive process.

Variable	Number of goalkeeper saves (%)	Number of goals scored (%)	Odds Ratio	CI (95%) Odds Ratio	*p*
Half					
1st half	698 (87.3)	102 (12.8)	1.388	1.059-1.820	0.017*
2nd half	759 (83.1)	154 (16.9)	1.00 (ref.)		
Match Status					
G2	257 (80.3)	63 (19.7)	0.551	0.374-0.811	0.003**
G1	186 (84.5)	34 (15.5)	0.739	0.468-1.165	0.192
P1	274 (85.9)	45 (14.1)	0.822	0.542-1.247	0.356
P2	303 (84.6)	55 (15.4)	0.744	0.501-1.105	0.142
G0	437 (88.1)	59 (11.9)	1.00 (ref.)		
Final result					
Draw	470 (86.2)	75 (13.8)	1.620	1.182-2.219	0.003**
Lose	515 (89.7)	59 (10.3)	2.256	1.614-3.154	< 0.001**
Win	472 (79.5)	122 (20.5)	1.00 (ref.)		

Note. Half: 1st Half – 00:01 - 25:00 minutes; 2nd Half – 25:01 – 50:00 minutes. Match Status: A win by more than one goal (G2); A win by a goal (G1); A tie (G0); Lose by a goal (P1); Loses by more than one goal (P2). Final result: Win – the observed team won the game; Draw – the observed teams draw the game; Lose – the observed team lost the game. ** ($p < 0.01$) * ($p < 0.05$).

As outlined in Table 4.4, the effectiveness of the opponents' goalkeeper is 43% lower after an interruption, when compared with situations of dynamic movement (e.g., interception, disarm, goalkeeper action and ball recovery; OR = 0.57; 95% CI: 0.43-0.75; $p < 0.001$). Goalkeeper effectiveness is lower when the opponents have a direct free-hit (OR = 0.22; 95% CI: 0.13-0.38; $p < 0.001$) and a penalty (OR = 0.12; 95% CI: 0.06-0.22; $p < 0.001$) when compared with an indirect free-hit. When the offensive sequence begins after an intervention from the goalkeeper, the probability the opponents' goalkeeper saving the shot is 98.5% higher (OR = 1.99; 95% CI: 1.10-3.59; $p = 0.023$) versus situations where the offensive process starts after a misplaced pass or a poorly directed shot.

When teams initiate the offensive process in the opposition's defensive area, they are 55% more likely to score a goal (OR = 0.46; 95% CI: 0.34-0.62; $p < 0.001$) than when the offensive action starts in their defensive area. Moreover, if the last pass is performed in the defensive area of the team in possession of the ball, the opposition goalkeeper had a 6.39 (OR) higher chance of being effective (95% CI: 2.54-16.08; $p < 0.001$). When the last pass was performed in the intermediate areas, the odds of the opposition goalkeeper performing a save were lower (OR = 2.80; 95% CI: 2.00-3.93; $p < 0.001$) than when the final pass was completed in the defensive area (OR = 6.39; 95% CI: 2.54-16.08; $p < 0.001$). However, the odds were higher than when performed in the opposition defensive area (OR = 1.66; 95% CI: 1.20-2.29; $p = 0.002$). When a shot at goal was performed in the opposition defensive area, goalkeepers were 66% less likely to save the shot (OR = 0.35; 95% CI: 0.23-0.54; $p < 0.001$) in comparison with shots performed in the intermediate area.

When an offensive action ends with a shot at the upper zones of the goal (upper right – OR = 0.18; 95% CI: 0.08-0.38; $p < 0.001$; upper centre – OR = 0.26; 95% CI: 0.12-0.56; $p < 0.001$; upper left – OR = 0.10; 95% CI: 0.05-0.21; $p < 0.001$) there was a higher chance of it being successful, when compared to shots in the centre of the goal (Table 4.5). The odds ratios presented in Table 4.5 indicate that a shot placed at the upper left of the goal has a 90% higher likelihood of being successful (OR= 0.10; 95% CI: 0.05-0.21; $p < 0.001$). Shots are 83% likely to result in a goal when placed in the upper right region of the goal (OR= 0.18; 95% CI: 0.08-0.38; $p < 0.001$) and have a 74% chance of scoring when directed in the upper centre section of the goal (OR= 0.26; 95% CI: 0.12-0.56; $p < 0.001$). When placed middle right (OR = 0.32; 95% CI: 0.15-0.69; $p = 0.004$) and middle left (OR = 0.41; 95% CI: 0.20-0.85; $p = 0.017$) of the goal, shots displayed lower values than in the upper zones of the goal. A shot to the medium left of the goal has a 59% probability of being successful, while a shot to the medium right area of the goal has a 68% chance of resulting in a successful outcome. Furthermore, a shot to the lower centre of the goal has a 55% probability of being successful, while a shot to the lower right and lower left zones of the goal are 59% and 74% likely to result with a goal scored, respectively.

When pertaining to goalkeeper technique, the "fleck" (OR = 0.30; 95% CI: 0.21-0.43; $p < 0.001$), "spatula" (OR = 0.33; 95% CI: 0.23-0.48; $p < 0.001$), and "side fall" (OR

= 0.21; 95% CI: 0.14-0.32; $p < 0.001$) had a lower effectiveness in comparison with the "knee on the floor".

Table 4.4 Differences in goalkeepers' performance according to the beginning and development of the offensive process.

Variable	Number of goalkeeper saves (%)	Number of goals scored (%)	Odds Ratio	CI (95%) Odds Ratio	*p*
Start of the offensive process					
After a break in play	405 (79.7)	103 (20.3)	0.572	0.434-0753	< 0.001**
Ij	8 (72.7)	3 (27.3)	0.300	0.075-1.193	0.087
Ipga	36 (90.0)	4 (10.0)	1.012	0.336-3.045	0.984
LD	72 (66.1)	37 (33.0)	0.219	0.126-0.380	< 0.001**
P	31 (50.8)	30 (49.2)	0.116	0.062-0.219	< 0.001**
Ipera	258 (89.9)	29 (10.1)	1.00 (ref.)		
Dynamic movement	1052 (87.3)	153 (12.7)	1.00 (ref.)		
Ipi	174 (85.7)	29 (14.3)	0.916	0.580-1.446	0.707
Ipd	159 (85.0)	28 (15.0)	0.867	0.545-1.379	0.547
Ipgr	182 (92.9)	14 (7.1)	1.985	1.099-3.585	0.023*
IpRB	537 (86.8)	82 (13.2)	1.00 (ref.)		
Area of the beginning of the offensive process:					
Opposition defensive area	458 (79.0)	122 (21.0)	0.459	0.340-0.620	< 0.001**
Intermediate area	304 (86.1)	49 (13.9)	0.759	0.521-1.106	0.151
Defensive area	695 (89.1)	85 (10.9)	1.00 (ref.)		
Area of the last pass:					
Opposition defensive area	433 (84.2)	81 (15.8)	1.657	1.201-2.287	0.002**
Intermediate area	579 (90.0)	64 (10.0)	2.804	2.000-3.931	< 0.001**
Defensive area	103 (95.4)	5 (4.6)	6.385	2.535-16.079	< 0.001**
Without interaction	342 (76.3)	106 (23.7)	1.00 (ref.)		
Shooting area:					
Opposition defensive area	1123 (82.9)	232 (17.1)	0.349	0.225-0.540	< 0.001**
Intermediate area	333 (93.3)	24 (6.7)	1.00 (ref.)		

Note. After a break in play: Start of the game (Ij); Regulatory disruption of the game in favour (Ipera); Goal from the opposing team (Ipga); Direct free-hit (LD); Penalty (P). Dynamic movement: Interception (Ipi); Disarm (Ipd); Goalkeeper action (Ipgr); Ball recovery (IpRB). Zone of the field – the rink hockey field is divided into 3 corridors (left, centre and right), 6 areas (1, 2, 3, 4, 5, and 6), and 18 zones, the defensive area corresponding to areas 1 and 2, areas 3 and 4 are the intermediate areas of the field and 5 and 6 are considered opposition defensive area. ** ($p<0.01$) * ($p<0.05$).

Table 4.5 Differences in goalkeepers' effectiveness according to opposition shot placement and goalkeeping technique.

Variable	With effectiveness from the goalkeeper (save), *n* (%)	Without effectiveness from the goalkeeper (goal), *n* (%)	Odds Ratio	CI (95%) Odds Ratio	*p*
Zones of the goal					
Upper left	70 (64.2)	39 (35.8)	0.100	0.047-0.212	< 0.001**
Lower left	197 (82.8)	41 (17.2)	0.268	0.131-0.552	< 0.001**
Middle left	242 (88.0)	33 (12.0)	0.410	0.197-0.853	0.017*
Upper right	82 (75.9)	26 (24.1)	0.176	0.081-0.382	< 0.001**
Lower right	244 (88.1)	33 (11.9)	0.413	0.198-0.860	0.018*
Middle right	144 (85.2)	25 (14.8)	0.322	0.150-0.692	0.004**
Upper centre	137 (82.5)	29 (17.5)	0.264	0.124-0.560	< 0.001**
Lower centre	162 (89.0)	20 (11.0)	0.453	0.206-0.995	0.049*
Middle centre	179 (94.7)	10 (5.3)	1.00 (ref.)		
Technique					
Fleck	248 (77.3)	73 (22.7)	0.301	0.211-0.428	< 0.001**
Spatula	208 (78.8)	56 (21.2)	0.329	0.225-0.480	< 0.001**
Side fall	105 (70.5)	44 (29.5)	0.211	0.138-0.323	< 0.001**
Others (Squatting; V position; Seated)	60 (87.0)	9 (13.0)	0.590	0.282-1.237	0.162
Knee on the floor	836 (91.9)	74 (8.1)	1.00 (ref.)		

Note. ** ($p < 0.01$) * ($p < 0.05$)

4.5. Discussion

This study aimed to analyse goalkeepers' performance and ascertain whether this was influenced by the opponents' offensive patterns, actions and proficiency. To the best of our knowledge, this is the first study that has analysed the within-match performance of goalkeepers concerning the opponents attacking play over a full season. Our results demonstrate that the opponents attacking play impacts goalkeepers' performance. These findings provide data that may assist coaches, practitioners and researchers with a clearer understanding of the demands of rink hockey goalkeepers and the patterns of offensive play, with the view to ultimately improving performance.

As observed in this study, goalkeepers were more effective in the first half compared to the second half. This may be related to the fact that there is an inherent reduction in the physical capacity of players and goalkeepers, which in turn leads to lower intensity during the second half (Kingman & Dyson, 1997). Similarly, a decline in physical performance in the second half of matches has been observed in other team sports such as soccer (Sarmento et al., 2014; Pratas, Volossovitch, & Ferreira, 2012; Sarmento et al., 2017) and rugby (Duthie et al., 2017). Indeed, a considerable change was made to the rules of the game in 2009, which involved a technical sanction (i.e., concede a direct free-hit) each time a team accumulates 10 fouls or five additional team fouls (World Skate, 2018). The application of this rule has resulted in more direct free-hits in the second half of matches, potentially as a result of physical and mental fatigue-related fouling. Furthermore, we established that goalkeepers are less effective when having to deal with direct free-hits and penalties (set pieces) in comparison with situations of indirect free-hit. The combination of the rule change, reduction in physical capacity and the reduced effectiveness of goalkeepers at saving direct free-hits, may explain the reason why goalkeepers are less effective during the second half.

Following our data, when the observed team had at least two or more goals scored than the opponent team, the effectiveness of the opponent goalkeepers is reduced by 45% versus a match that is tied. This may be related to the fact that when teams are losing, they tend to take more risks and as a consequence are exposed defensively to counter-attacks. By assuming a more offensive approach and becoming more exposed to dynamic counter-attacking play, teams will often encounter situations of numerical disadvantage. Additionally, in sports such as soccer (Sarmento et al., 2018) teams that adopt a counter-attacking style of play tend to be more effective. This premise may apply to rink hockey, and thus, coaches must prepare teams (including goalkeepers) to be able to deal with this overload from a tactical and technical standpoint to limit opposition space and delay attacks.

According to our findings, the effectiveness of the rink hockey goalkeeper is reduced when a given offensive action starts following a break in play. However, there are situations where an attack can commence with an interception following a misplaced pass or shot, a disarm or recovery of the ball. In line with our data, it can be deduced that when possession was regained nearer to the opposition goal, the opponents'

goalkeeper was less likely to save the subsequent shot. Although from a different sport, our results are similar to those of (Gamble, Bradley, McCarren, & Moyna, 2019) as they investigated the influence of tactical and situational variables on offensive sequences during elite football matches. They concluded that when teams regain ball possession in more offensive areas, they are more likely to score during a given attacking phase of play. In rink hockey, the defensive and intermediate areas of the rink (zones 1, 2, 3 and 4; see Figure 4.1) are the desirable areas in which to start offensive actions (Duque, 2004; Rosa, 2006; Clérigo, 2006; Ferreira, 2005; Ferreira, 2003). This information could assist coaches when work on developing strategies that develop the goalkeepers' ability to distribute the ball effectively into the desired zones.

Our results suggest that where an interaction (pass) between players occurred, the likelihood of scoring a goal was reduced. However, it is acknowledged that this information may be influenced by direct free-hits and penalty data. It can also be deduced that the effectiveness of the goalkeeper is reduced when the last interaction is performed in the zones nearer the opposition defensive area. It may be plausible to suggest that the goalkeeper has less time to react and adapt favourable positioning in relation to the completion of opponents quick manoeuvring of the ball. These observations reveal important information about the areas and actions that make it difficult for goalkeepers to prevent a goal. Conversely, goalkeeping coaches and/or individuals regarded as being involved in the tactical preparations of goalkeepers may utilise this data to their advantage.

As outlined in this study, goalkeepers tend to be less effective when shots are placed in the upper zones and more effective in the middle of the goal. Our data is similar to Kingman and Dyson (2001), which analysed the performance of six English national Premier League rink hockey matches. They found that 38.2% of the shots placed in the top right of the goal were successful (in our study we concluded that 35.8% of the goals are scored in the upper left of the goal), whereas only 5.9% of shots directed towards the centre of the goal resulted in a goal scored. In a study performed by Almeida, Volossovitch and Duarte (2016), the authors analysed a total of 536 penalties from 2010-2011 to 2014-2015 from the UEFA Champions and Europa league (football) and also concluded that players should direct the shots to the upper

corners of the goal because those were the zones of the goal where the probability of ending in a goal was higher.

Furthermore, the most frequent technique used was the "knee on the floor" with goalkeepers utilising this technique to attempt to save 53.1% of shots on goal. From all the techniques considered, the "knee to floor" was the most successful method of shot-stopping. Moreover, we found the "fleck" technique was ineffective in our study. In a study performed by Sousa et al. (2018) coaches considered "fleck" as an "optimum position" to save a shot at goal (defined as a posture adopted by the goalkeeper that allows to carry out a save with efficiency and economy of effort). Comparing the two techniques, there is 70% more chance of conceding a goal using the "fleck" technique than the "knee on the floor". This technique (fleck) requires a great deal of motor coordination and strength in the support arm and may be an explanation as to why this complex technique is less effective.

4.6. Conclusion

These contemporary data provide a better understanding of the performance of professional hockey goalkeepers in relation to the attacking play of rink opposition hockey teams. The results of this investigation could be useful for coaches and researchers to understand the profile of the offensive process in rink hockey and also the effectiveness of goalkeepers. In this sense, new training strategies can be implemented to help improve goalkeepers' performance in relation to the opposition teams attacking play. These may include, working on saving set pieces, distributing the ball into opposition areas and performing effective techniques, such as the "knee on the floor". Conversely, these findings may assist attacking teams in exploiting goalkeepers by manipulating the goalkeeper positioning through quick movements and passes, and placing the ball in the upper section of the goal in both open play and set pieces.

CHAPTER FIVE: Study Four

5. Anthropometric characteristics of male rink hockey goalkeeper's according to their competitive level

Reference: Sousa, T., Valente-dos-Santos, J., Sarmento, Duarte, J. P., H., Adam, F., , & Vaz, V. (*Accepted on 06/11/2020*). "Anthropometric characteristics of male rink hockey goalkeeper's according to their competitive level". *Revista Andaluza de Medicina del Deporte.*

5.1. Abstract

This study aimed to evaluate the anthropometric characteristics of male rink hockey goalkeepers and to compare the variation according to their competitive level (international *vs.* non-international).

Body mass, stature, sitting height, arm span, waist and hip circumferences and four skinfold measurements (triceps, medial calf, subscapular and supraspinale) of international (n = 12) and non-international (n = 23) goalkeepers were taken. Body mass index (BMI, weight/height^2), the sum of four skinfolds, the sitting height/stature ratio, waist/hip ratio and the relative arm span were also calculated.

International rink hockey goalkeepers have lower values of subcutaneous adiposity for the sum of the four skinfolds (P = 0.042; d = 0.76) particularly in the triceps (P = 0.016; d = 0.87) and are taller than non-international goalkeepers (+3.8 cm [2.2%]; 180.5 ± 7.0 vs. 176.6 ± 4.8 cm; t = 1.920; P = 0.064; d = 0.65).

The findings could indicate that stature and body fat may have important implications for scouts regarding the selection process and coaches that work with players on developing performance. Future research should investigate the extent to which different anthropometric measures influence performance in rink hockey goalkeepers.

Keywords: anthropometry; adiposity; body fat distribution; skinfold thickness.

5.2. Introduction

The importance of anthropometric characteristics in sports performance is well established (Santos et al., 2014; Massuça et al., 2014; Malina, 2007). Athletes with an optimal anthropometric profile for a specific sport are adjudged to be more successful. This anthropometric information has been used to evaluate the training status and identify talented male and female athletes (Massuça & Fragoso, 2015).

There are numerous different methods for estimating body composition that provides reasonably similar assessments of body composition, being that the body mass index (BMI) (weight [kg]/height^2 [m]) and skinfold thicknesses are perhaps the most widely used anthropometric indicators for body composition. Despite this the use of the BMI in a population of athletes' presents some limitations, given to the large body size (height and mass) and relative leanness, also, skinfold measurements present some degree of error. However, these two methods are a basic tool for estimating body size and configuration, despite having limited accuracy, because they are portable and inexpensive, the procedures are non-invasive and minimal training is required (Malina, 2007).

Most research that has assessed the anthropometric characteristics of rink hockey players are conducted in youth athletes (Coelho-e-Silva et al., 2012; Valente-dos-Santos, Coelho-e-Silva et al., 2013). However, sport-specific body composition profiles have been developed by use of the Dual-energy X-ray absorptiometry (DXA) and anthropometry (Santos et al., 2014). This involved a sample of adult male rink hockey players (n = 49), whereby the majority were outfield players. However, despite the growing research effort afforded to rink hockey goalkeepers (Sousa et al., 2018, 2020), there remains a paucity of work assessing the anthropometric profiles of this bespoke position.

Several studies have profiled the anthropometric characteristics of elite ice-hockey players and the impact on athletic selection and performance (Vescovi et al., 2006; Sigmund et al., 2016). In these studies, it was identified that stature and body mass play an important role in the selection process with goalkeepers being the tallest players. However, little is known as to what extent these findings translate to rink hockey goalkeepers.

Anthropometric profiles of elite athletes can provide pertinent information regarding the morphological requirements to compete at a higher level. Therefore, the purpose of this paper is twofold: 1) to evaluate the anthropometric characteristics of male rink hockey goalkeepers, and 2) to compare the variation according to their competitive level (international vs. non-international). This information may be useful to scouts and coaches for talent identification and development procedures. We hypothesised that international goalkeepers would have a greater stature, lower body mass and reduced body fat compared with non-international goalkeepers.

5.3. Methods

The study received approval from the scientific committee and was conducted in accordance with recognised ethical standards (Harriss & Atkinson, 2009). Each team provided written informed consent, while assent was obtained from individual athletes. Participants were also informed that participation was entirely voluntary and that they could withdraw at any time. This research was observational in nature and as such, no intervention was undertaken.

Sample

A formal request to participate in the study was sent to all teams participating in the *Euro male senior Azeméis 2016* as well as to all teams of the Portuguese first league. Six of the eight teams participating in the *Euro male senior Azeméis 2016* agreed to participate in this study, while only one of the fourteen teams of the Portuguese first league did not participate in this study. The sample included 35 male rink hockey goalkeepers. The goalkeepers were classified as international and non-international. Twelve (two from each national team) international goalkeepers were selected for their national teams (Portugal, Spain, France, Germany, England and Austria) and participated in the *Euro male senior Azeméis 2016*, aged between 18 and 48 years old (29.9 ± 8.1). The non-international (23 goalkeepers) played in the Portuguese first league, aged between 17 and 42 years old (28.9 ± 7.2). No differences were observed in training time between the international goalkeepers (3.6 ± 1.7 sessions/week) and non-international goalkeepers (4.1 ± 0.7 sessions/week). All goalkeepers participated in a 10-month competitive season (September – June), involving 1 – 2 games/week.

Anthropometry

Body mass, stature, sitting height, arm span, skinfold assessments at four anatomical locations (triceps, medial calf, subscapular and supraspinale), and waist and hip circumferences were taken by a singled experienced observer following the protocol described in Lohman, Roche, & Martorell (1988). Goalkeepers wore shorts and a T-shirt and shoes were removed. Body mass index (BMI, weight/height^2), the sum of four skinfolds (Figueiredo, Gonçalves, Coelho-e-Silva, & Malina, 2009), the sitting height/stature ratio (Malina, Bouchard, & Bar-Or, 2004), the waist/hip ratio (World Health Organisation, 2008) and the relative arm span (Watts, Joubert, Lish, Mast, & Wilkins, 2003) were calculated. Skinfolds were measured to the nearest mm using a Lange caliper (Beta Technology, Ann Arbor, MI, USA). Technical errors of measurement for body mass (0.47 kg), stature (0.27 cm), sitting height (0.31 cm), arm span (0.74 cm), skinfolds (0.47 – 0.72 mm) and circumferences (0.29 – 0.74 cm) were well within the range of several health surveys in the United States and a variety of field surveys (Malina et al., 2004).

Statistical analysis

The Kolmogorov-Smirnov test was used to examine the degree of normality. Student *t*-tests were used to compare the anthropometric characteristics of the international and non-international goalkeepers. The magnitude of the effects was interpreted as follows: < 0.20 (trivial); 0.20 to 0.59 (small); 0.60 to 1.19 (moderate); 1.20 to 1.99 (large); 2.00 to 3.99 (very large); ≥ 4.00 (extremely large) (Hopkins, Marshall, Batterham, & Hanin, 2009). Alpha was accepted as $p \leq 0.05$ prior to analyses. Statistical analysis was completed using IBM SPSS Statistics (version 22.0, Chicago, Illinois, USA).

5.4. Results

International goalkeepers, on average played more games than non-international rink hockey goalkeepers (+7.1 games [24%]; 29.5 ± 7.2 vs. 22.4 ± 14.6 games; $t = 1.931$; $P = 0.062$; $d = 0.61$) (Table 5.1 and Figure 5.1).

Table 5.1 Characteristics of the sample and comparisons between international and non-international rink hockey goalkeepers.

	International level (*n* = 12)	**Non international level (*n* = 23)**	**Comparison**		**Effect size**	
Variable	**Mean ± SD**	**Mean ± SD**	***t***	***P***	***d*-value**	**qualitative**
Chronological age (years)	29.9 ± 8.1	28.9 ± 7.2	0.391	0.698	0.18	trivial
Training experience (years)	22.0 ± 7.7	22.4 ± 6.5	-0.159	0.874	0.06	trivial
Training sessions (sessions/week)	3.7 ± 1.7	4.2 ± 0.8	-0.969	0.350	0.33	small
Games played (number)	29.5 ± 7.2	22.4 ± 14.6	1.931	0.062	0.61	moderate

Compared to non-international, international rink hockey goalkeepers are taller (+3.8 cm [2.2%]; 180.5 ± 7.0 vs. 176.6 ± 4.8 cm; t = 1.920; P = 0.064; d = 0.65). International goalkeepers had lower values of subcutaneous adiposity on the sum of 4 skinfolds compared with non-international goalkeepers (-14.6 mm [32.9%] 44.4 ± 16.6 vs. 59.0 ± 19.7 mm; t = -2.119, P = 0.042; d = 0.76).

International goalkeepers have lower fat content in the triceps (-3.8 mm [28%] 9.9 ± 4.1 vs. 13.7 ± 4.3 mm; t = -2.527; P = 0.016; d = 0.87). Moderate differences existed between groups in the supraspinale skinfold measurement (-6.0 mm [29%] 14.5 ± 6.9 vs. 20.5 ± 10.0 mm; d = 0.64), however this did not reach statistical significance (P = 0.073) (Figure 5.1 and Table 5.2).

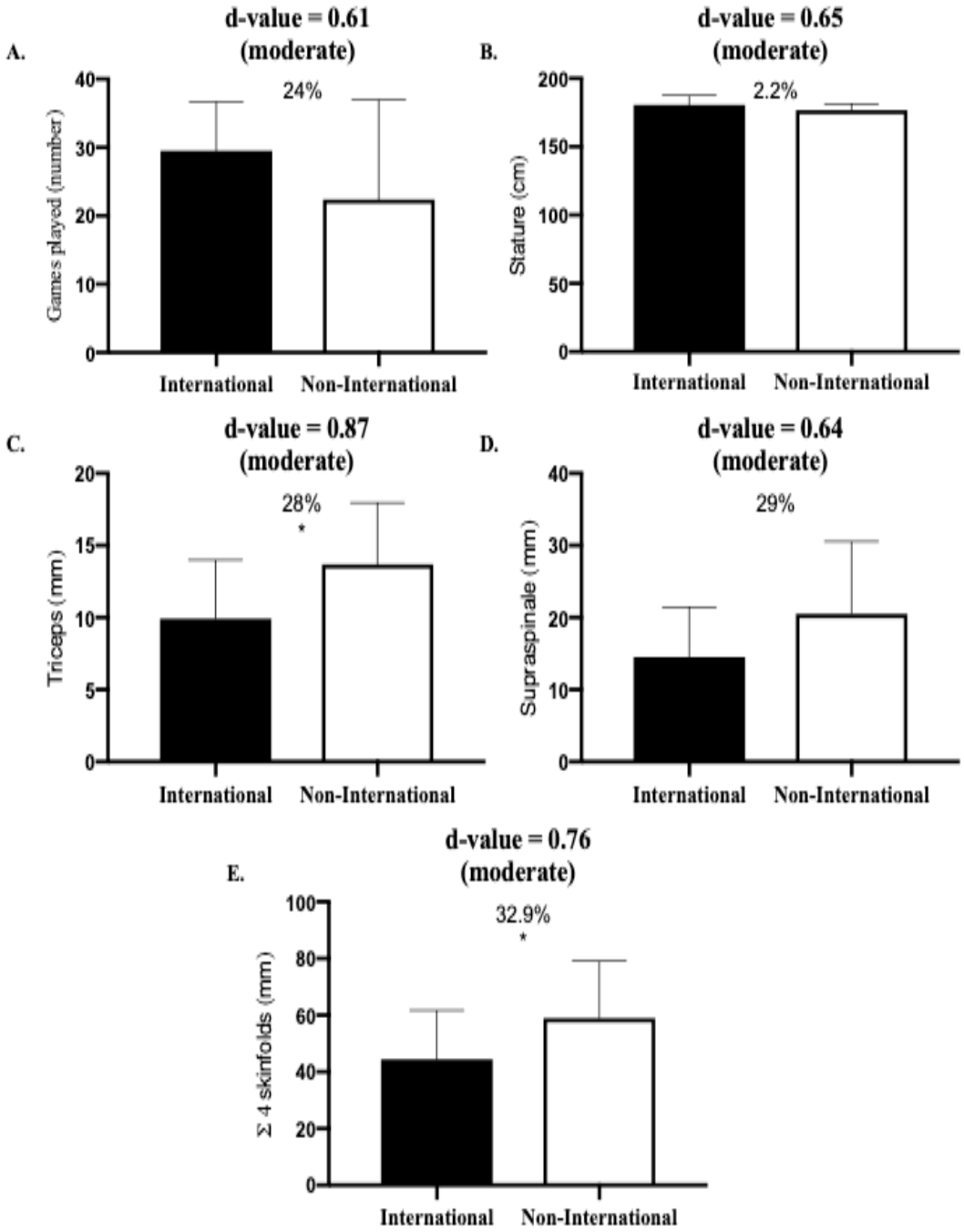

Figure 5.1 Games played (A), stature (B), triceps (C), supraspinale (D) and, Σ 4 skinfolds (E) in international rink hockey goalkeepers (black bars) and non-international rink hockey goalkeepers (white bars). Mean differences between groups (international vs. non-international level). * Indicates the difference between the groups (P<0.05).

Table 5.2 Descriptive statistics for anthropometric and composite anthropometric variables and comparisons between international and non-international rink hockey goalkeepers.

	International level (*n* = 12)	**Non international level (*n* = 23)**	**Comparison**		**Effect size**	
Variable	**Mean ± SD**	**Mean ± SD**	***t***	***P***	***d*-value**	**qualitative**
Stature (cm)	180.5 ± 7.0	176.7 ± 4.8	1.920	0.064	0.65	moderate
Body mass (kg)	81.0 ± 12.3	81.4 ± 7.5	-0.118	0.908	0.04	trivial
Sitting height (cm)	95.3 ± 3.7	94.7 ± 3.1	0.525	0.603	0.18	trivial
Arm span (cm)	190.3 ± 8.7	186.6 ± 5.6	1.517	0.139	0.10	trivial
Skinfolds:						
Triceps (mm)	9.9 ± 4.1	13.7 ± 4.3	-2.527	0.016	0.87	moderate
Subscapular (mm)	13.3 ± 5.0	15.9 ± 6.1	-1.302	0.202	0.44	small
Supraspinale (mm)	14.5 ± 6.9	20.5 ± 10.0	-1.852	0.073	0.64	moderate
Medial Calf (mm)	6.8 ± 3.3	8.8 ± 3.6	-1.623	0.114	0.55	small
Waist circumference (cm)	84.5 ± 8.6	88.0 ± 7.0	-1.293	0.205	0.45	small
Hip circumference (cm)	97.8 ± 5.7	99.6 ± 4.3	-1.061	0.296	0.36	small
BMI (%)	24.8 ± 2.8	26.1 ± 2.4	-1.486	0.147	0.50	small
Σ 4 skinfolds (mm)	44.4 ± 16.6	59.0 ± 19.7	-2.119	0.042	0.76	moderate
Sitting height/stature ratio (%)	52.8 ± 1.1	53.6 ± 1.5	-1.647	0.109	0.56	small
Waist/hip ratio (%)	86.3 ± 4.6	88.3 ± 4.7	-1.177	0.248	0.41	small
Relative arm span	105.4 ± 2.0	105.7 ± 2.4	-0.310	0.759	0.13	trivial

5.5. Discussion

The purpose of this study was to evaluate the anthropometric characteristics of male rink hockey goalkeepers concerning their competitive level. The results obtained in our study demonstrate that there are some differences in stature between international and non-international goalkeepers, although they are not statistically significant, have less body fat and compete in a higher volume of games compared with non-international rink hockey goalkeepers. These data are novel and have implications for rink hockey talent identification staff networks attempting to identify goalkeepers based on their physical characteristics.

In the present study, international goalkeepers are taller compared to non-international goalkeepers. The sample international goalkeepers are in the 95th percentile while non-international goalkeepers are in the 75th percentile concerning the reference population of rink hockey players (Santos et al., 2014). However, when comparing our results with professional ice-hockey goalkeepers, the values of our population are substantially lower (Sigmund et al., 2016; Vescovi et al., 2006). These results are surprising given the similar competitive level and nature between the sports. Stature can determine the selection of goalkeepers, with those that are taller typically preferred in sports such as handball (Justin et al., 2013), ice hockey (Sigmund et al., 2016; Vescovi et al., 2006) and football (Lago-Peñas, Casais, Dellal, Rey, & Domínguez, 2011b). Therefore, determining the extent to which stature impacts upon goalkeeper performance is an avenue for future work.

Despite no significant differences for body mass existing between groups, international goalkeepers have lower values of BMI than the non-international. According to the World Health Organization (2008), the BMI of the international goalkeepers is considered normal (18.5 – 24.9) while non-international goalkeepers are overweight (25.0 – 29.9). However, these data must be interpreted with caution as the inherent limitations associated with BMI, such that this measure does not account for differences in fat and muscle mass, which could lead to erroneous and misleading conclusions (Sardinha et al., 2012).

Moderate between-group differences in the sum of the four skinfolds and each of the individual sites were established. Specifically, our results show that non-international goalkeepers have higher values of subcutaneous adiposity, which could be explained by the small sample used for the study. Rink hockey goalkeepers must perform dynamic movements, and maintain postural stability, whilst restricted by protective gear and in a crouched position (Coelho-e-Silva et al., 2012; Kingman & Dyson, 2001; Sousa et al., 2018, 2020). This additional fat mass may have a major impact on non-international goalkeepers mobility, postural stability and performance (Mala et al., 2015; Reilly & Doran, 1996). The differences in subcutaneous adiposity between groups could be a consequence of the additional games played by the international goalkeepers. It is well documented that higher levels of training and competition exercise are correlated with a reduced body fat percentage (Ostojic, 2002; Silva & Silva, 2017). However, a causal relationship between the number of games played and

the amount of body fat cannot be confirmed. Further studies involving rink hockey goalkeepers should investigate the relationship between body compositions on subsequent performance.

Although the current study provides novel insights into such a specific population, our research has limitations. Specifically, the sample size was relatively small and only represents goalkeepers who had agreed to participate in the study. The use of anthropometry has some degree of measurement error, however, is still a feasible tool available for coaches as opposed to expensive technology (e.g., air displacement, DXA etc.) (Malina, 2007). The discrepancy in the number of goalkeepers used for each group could potentially confound the statistical inferences drawn from our research. Furthermore, there are disparities in training volume between national teams from different countries, thus the extent to which our findings translate to the rink hockey goalkeepers in other countries is unknown. Anecdotally, it is expected that international goalkeepers are superior to non-international on performance. However, due to the absence of performance measures, this premise was unable to be confirmed, leaving our data without valid conclusion as to how these measures influence performance. Therefore, this opens an avenue for future investigative work that could quantify a range of performance metrics alongside taking anthropometric measures to determine whether correlations are present between the two variables.

This study assessed the anthropometric characteristics of male rink hockey goalkeepers according to their competitive level (international vs. non-international). In agreement with the hypothesis, our findings suggest that international goalkeepers, play more games, are taller and have less subcutaneous adiposity compared to non-international goalkeepers. The differences found between the two groups could indicate that stature and subcutaneous adiposity can be used for scouting networks as part of a talent identification tool. However, it is key that future studies assess the effect that stature and subcutaneous adiposity have on subsequent performance in rink hockey goalkeepers.

CHAPTER SIX: Study Five

6. The perceptions of elite rink hockey head coaches: preparation/observation, interventions and the rink hockey goalkeeper

Reference: Sousa, T., Sarmento, H., Field, A., Vaz, V., (*under review*). "The perceptions of elite rink hockey head coaches: preparation/observation, interventions and the rink hockey goalkeeper". *International Journal of Performance Analysis in Sport.*

6.1. Abstract

The study explored the perception of rink hockey head coaches concerning the use of performance analysis as a tool to assist training and match preparation, observation, interventions and the rink hockey goalkeeper.

Seven experienced First Division Portuguese rink hockey coaches were included in the study. Semi-structured interviews were carried out and the data were analysed through inductive and deductive content analysis. Several themes emerged from the interviews including "observation" and "intervention" and from those themes emerged a third theme that we called "the rink hockey goalkeeper".

Rink hockey head coaches prefer to analyse the opponents themselves to plan training, as well as to assist with tactical preparation and implement within-match strategies. They consider video analysis an important tool to analyse the opponents' strengths and weaknesses, with particular focus on the opponent's goalkeeper. The game moments considered important for analysis are: (1) defensive organization; (2) offensive organization; (3) defensive transition; (4) offensive transition, and (5) set pieces. The training intervention involves the adaption of training exercises, whereby information is communicated during meetings. Head coaches consider effectiveness, technical quality and a good positional sense important for the goalkeeper.

These data have implications both from a performance and training practice perspective. Future research should focus on players and goalkeepers perspectives.

Keywords: roller hockey; match analysis; planning; practice; observation.

6.2. Introduction

Rink hockey is characterized as being a fast-paced game with a large number of ball possessions (Duque, 2004; Rosa, 2006; Vaz, 2011). Nonetheless, the dynamics of the game does not differ much from other invasion team sports, despite the possibility of playing behind the goals (Oliveira, Clemente, & Martins, 2015). Existing match analysis data within the literature are targeted at increasing knowledge about the demands of the game through studying age-related differences in under-17 (U-17) (Rosa, 2006; Duque, 2004 & Vaz, 2011), under-20 (U-20), and senior players (Ferreira, 2005; Clérigo, 2006 & Ferreira, 2003). In those studies, the authors have focused their attention mainly on: (1) ball possession; (2) type of attack, and (3) finishing actions. Other studies are focused on players' activity profiles and contain other information related to: (1) players' position (Kingman & Dyson, 1997; 1997b; Sousa, Sarmento, Marques, Field, & Vaz, 2020; Trabal & Riera, 2020); (2) match half (Kingman & Dyson, 1997b); (3) phase of the competition (Bastos, 2005); (4) age group (Oliveira, Clemente, & Martins, 2015; Santos, 2006; Vaz, 2011); (5) game result (Rosa, 2006; Duque, 2004; Ferreira, 2003; Kingman & Dyson, 1997b), and; (6) home advantage (Arboix-Alió, Buscà, Trabal, Aguilera-Castells, & Sánchez-López, 2020b).

Head coaches are required to be able to make quick decisions within an unpredictable environment while adapting to external factors (Serrano et al., 2013). Therefore, and to achieve sporting success, head coaches must prepare for and retrieve information from previous games of their own and/or the opposite teams' performance in order to identify strengths and weaknesses, enabling to recognize tactical patterns and how to counteract them (Almeida, Sarmento, Kelly, & Travassos, 2019; Butterworth, Turner, & Johnstone, 2012). Collecting that information will allow coaches to improve the coaching process, the understanding of the game and the development and improving training practice and the player performance (O'Donoghue, 2009b; Sarmento, Bradley, & Travassos, 2015). However, and, despite being well recognised, the importance of performance analysis in many sporting contexts and skills levels is still unclear on how to head coaches' use performance analysis to optimise teams' and players' performance (Butterworth et al., 2012).

Performance analysis has evolved from statistical data collected by hand on paper to computer systems, where statistical information has been now linked to video (Groom & Cushion, 2004; Hughes & Franks, 2005). While, for some coaches, this evolution could be seen as a threat (Butterworth et al., 2012), for others, it is well accepted within the overall coaching process. Performance analysis can provide objective feedback, develop knowledge about the opponents and also about their own game performance (Butterworth et al., 2012; Almeida et al., 2019). At the same time, it enables to coach to develop their players in areas such as technical and tactical knowledge, critical thinking, decision-making and confidence (Groom & Cushion, 2004). Thus, coaches can use performance analysis data to provide information to their players through adaptation of training exercises, video analysis and also team meetings (Sarmento, Pereira, et al., 2014; Sarmento et al., 2015).

Since there is currently thought to be a disconnection between coaching practice and research, interest, it is essential to receive head coach feedback to bridge the gap together between evidence-led research and applied practice, ultimately to improve practice and match preparation (Carling, Wright, Nelson, & Bradley, 2014; Sarmento, Bradley, & Travassos, 2015). Interviewing head coaches can lead to a better understanding of how they perceive the game and, therefore, to identify and explore the most appropriate methods which uncover the opposition team tactics and match the dynamics (Sarmento, Pereira, Anguera, Campaniço, & Leitão, 2014). This approach is important to understand the type of match analysis used by head coaches, as well as how this information is used to provide players' feedback and adapt their training sessions (Sarmento et al., 2015). However, to the best of our knowledge, there are no studies that focus on rink hockey coaches and their insights into game understanding, the decision-making processes, and the complexities involved with applied practice. In this sense, it is important to explore the perceptions of rink hockey coaches in relation to the observation of the opponent/own team, intervention and adaption of training practices and the bespoke position of the rink hockey goalkeeper.

6.3. Methods

Participants

Seven Portuguese First Division rink hockey head coaches (coaching experience: 19.0 ± 8.4 years; range: 5 to 31 years) took part in the study. To be included, the head coaches (1) provided informed consent; (2) were involved in coaching at the time of interviews, and; (3) were working as head coaches within the Portuguese First Division. Three of the head coaches had had experience as national team head coaches, one head coach had been the former U-20 Portuguese national head coach; another was the current head coach of the Portuguese national team and one had been the former head coach of the Spanish national team. All head coaches had an assistant coach in their technical staff with exception of head coach 7. Three of them had a performance analyst in the club (head coaches 1, 2 and 5) and one (head coach 7) has been using the services of an external performance analyst.

Because of the in-depth nature of each interview, and the number of high calibre teams included from the first league (i.e., 7 out of 14 [50%]), seven head coaches were considered representative of the elite rink hockey population.

Instruments

Semi-structured interviews were conducted as per previously published works (Bardin, 1977; Ghiglione, Matalon, Pires, & de Saint-Maurice, 2001; Sarmento, Pereira, Anguera, Campaniço, & Leitão, 2014).

The interview questions were designed to identify the most relevant issues to the head coach and to focus on these issues in detail. To ensure content validity, the interview questions were designed systematically according to common qualitative research methods (Ghiglione et al., 2001; Sarmento, Pereira, et al., 2014). This involved preparation and discussion of previous versions of the interview guide, based on the following steps (Sarmento, Pereiraet al., 2014): (1) preparation of the first version of the interview questions based on the specific outcomes of the study; (2) evaluation of the interview transcripts by two senior researchers with substantial experience with interview methods, two rink hockey head coaches, and two experienced rink hockey

goalkeepers; (3) several alterations carried out based on these evaluations; (4) a pilot interview with a Portuguese First Division head coach; (5) minor alterations to the transcripts resulting from the reflections of the pilot interview; (6) resubmission of this version of the transcripts to the evaluators. This ultimately resulted in the final version of the interview questions. The interview was composed of nine general questions with open answers. The answers were used as a starting point for a more in-depth discussion on the tasks of observation and intervention.

Data collection

All the interviews were performed by the first author (TS), between 11th and 29th of November 2019. The same format was used during each interview that began with the disclosure of general study information and the purpose of the research. Finally, the interviewer focused on the coaches' background and demographic information. Each interview lasted between 43 minutes and 79 minutes and was transcribed in a Microsoft Word document using the Cambria font with size 12 and 1.0 spacing (68 pages). All the coaches were assigned a transcription number to ensure coach anonymity.

Data analysis

The purpose of data analysis was to identify categories which had emerged from the unstructured data and which represented the organization and utilization of expert rink hockey head coaches' knowledge (Sarmento, Pereira et al*.,* 2014).

Data analysis was performed using qualitative content analysis (Coté, Saimela, Trudel, Baria, & Russell, 1995; Bardin, 1977; Sarmento, Pereira et al., 2014), using a combination of inductive and deductive approaches (Patton, 1990). The categories of "Preparation/Observation", "Intervention" and "The Rink Hockey Goalkeeper", and the sub-categories of Coach role in the analysis; How; What; Why; Meetings; Adaptation of training exercises; Specificities of the goalkeeper in rink hockey; Anthropometric profile and Technique versus effectiveness were established a *priori. A posteriori,* during the qualitative analysis, emerged other subcategories such as: Head coach; Assistant coach; Analyst; Monitoring; Number of observation; Goalkeepers; Global dynamics; Characteristics of the players; Moments of play;

Statistical data; Behaviour opponent coach; Information about opponent's team; Information about opponent's goalkeepers; Goalkeepers relevance; Game model; Adaptation to coaches' defensive principles; Influence in teams objectives; Influence in the defensive/offensive organization; Stature; Arm span; Body mass; Physical characteristics; Technique; Pedagogical approach; Positioning, and; Recruitment.

The text units were coded and those with comparable meanings were organized into specific categories. Two researchers conducted the analysis independently (TS and HS) to ensure data interpretation and theme credibility was suitable. The software QSR NVivo 12 was used to code the transcripts of the interviews.

All researchers were trained in qualitative research methods as outlined by several sources (Côté, Salmela, Baria, & Russell, 1993; Creswell, 2007; Lincoln, 1995; Smith & Caddick, 2012). Member checks (the most crucial technique for establishing credibility) occurred at the end of each interview during a debriefing session and a peer review process, which had involved a neutral party, was developed in order to ensure data credibility. An independent researcher examined the meaning units and any disagreements were debated until a consensus had been reached by the research team.

6.4. Results

Following the content analysis of the data, three main categories were identified: (1) preparation/observation; (2) intervention, and (3) the rink hockey goalkeeper.

Preparation/Observation

We define the category of "preparation/observation" in this study as being the procedures involved with analysing the opponents and their own team, as well as the understanding of who deals with the performance analysis, how they do it, as well as the knowledge of what is there to be analysed and why (Figure 6.1).

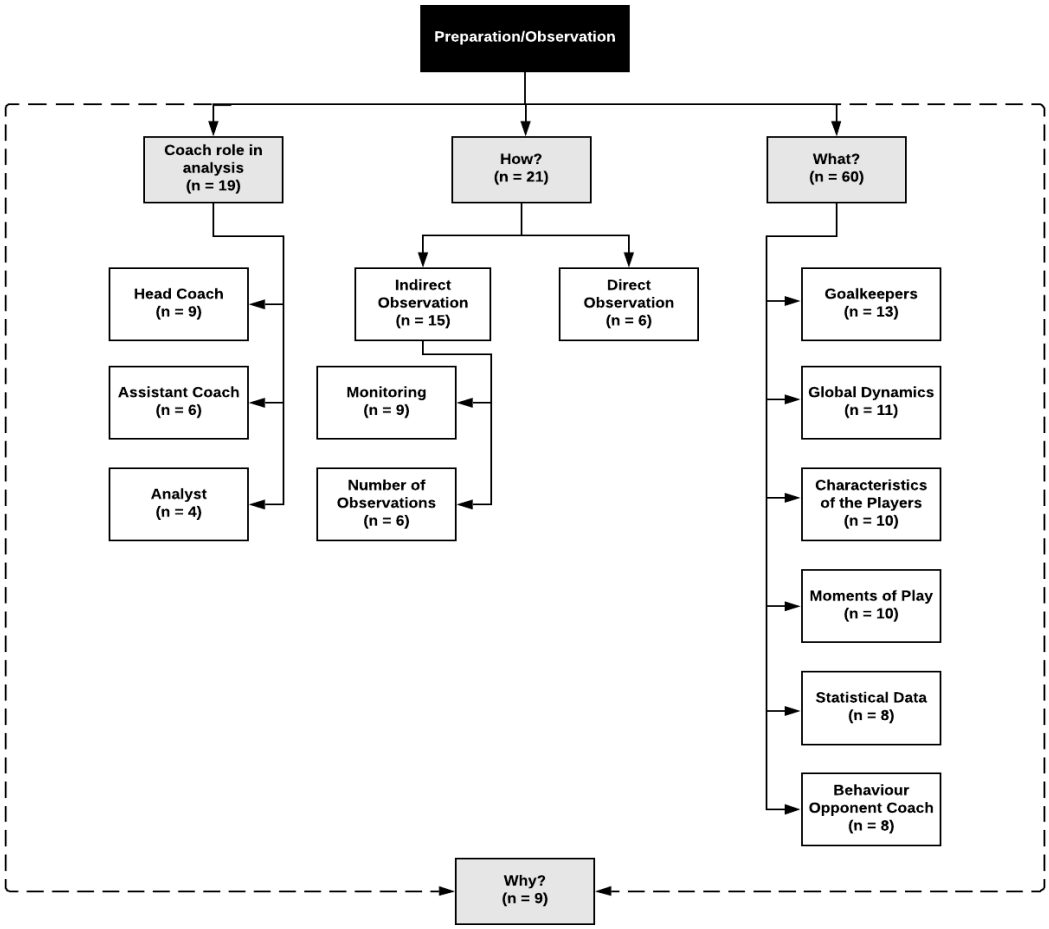

Figure 6.1 Graphical representation of the sub-categories for the category "Preparation/Observation". The number "n" reported represents the number of independent mentions of this idea/concept by the seven rink hockey coaches.

Coach role in the analysis

In this subcategory, we tried to understand who conducts performance analysis of the opponent/own team. We have concluded that it is the head coach who largely performs it. In some cases, rink hockey head coaches share the observation tasks with the assistant coach or an analyst of the club, to reduce their workload. However, most of the time, head coaches assign others to conduct the analysis of set pieces, because they feel the need to see the sessions from a different perspective to be able to view the problems which the opponent teams can cause in order to implement strategies and training plans, accordingly. Four of the interviewees did assume that they had had the help of an analyst to support the analysis of the opponent teams.

> *"The video analysis of our opponents goes through me. Regardless of whether I have two assistant coaches and being able to delegate it, it is a process that I absolutely do not want to be dissociated from."* (Head coach 6)

> *"In the beginning, it was me who did everything, cuts, editing, etc. Not now. Now I have an assistant coach who helps me, fortunately, because it saves me a lot of work"* (Head coach 2)

> *"I work with an analyst who helps me with the opposing analysis. I send him two games and he analyses them"* (Head coach 7)

How?

A total of three head coaches stated they liked to analyse the opponents during live competition. However, they reported that this was not always possible due to competitions schedule constraints. Nevertheless, head coaches highlighted the importance of observing the opponents during live situations as they could detect key information, which could not be identified *via* video analysis.

> *"It is always important to do a live observation of our opponents and get to know the reality of what we are going to find in competition, because often on video there are things that we miss. One of the big problems that we feel in video analysis is the difficulty that exists in having the perception of the movement of all players."* (Head coach 2)

All head coaches have highlighted that "indirect observation" was an important tool for opponent analysis. Had it been highlighted by the available literature in performance analysis, video would be a tool which would facilitate the analyses of the opponent/own team (Hughes & Franks, 2004; Liebermann & Franks, 2004; McGarry, 2009; Groom & Cushion, 2004).

Head coaches were found to observe between 2 – 7 games of the opponent team and reported that they had tried to analyze opponent teams playing in similar situations to which the game would take place (e.g., against opponents with a similar game model, away or home depending, where the game would take place). This goes into an

agreement with previous studies in football (Sarmento, Pereira, et al., 2014; Travassos, Davids, Araújo, & Esteves, 2013).

> *"We try to find technical/tactical behaviours that are repeated in games more similar to what we are going to play (...) we try to find information more similar to what can happen in our game."* (Coach 4)

What?

The interview questions attempted to extract information to assist with understanding where rink hockey head coaches focus their attention when analysing opponents' teams.

For the rink hockey community in general (players, coaches and fans) the goalkeeper plays a major role in teams' sporting success (Sousa, Sarmento, Harper, Valente-dos-Santos, & Vaz, 2018; Sousa et al., 2020; Trabal, 2016; Trabal, Daza, & Arboix-Alió, 2020). According to the opinions of our respondents, the analysis of the opponent "goalkeeper" is one of the most important tasks. Head coaches try to identify weaknesses in opponent goalkeepers, which can be exploited by their players.

> *"I look for weaknesses in the opposing goalkeepers. Sometimes those weaknesses arise from a specific moment of the game and not because he has technical weaknesses but rather because the situation forces him to take bad decisions. All scenarios must be analysed. I play counter-attacking hockey, direct hockey, and focus on the behaviour of goalkeepers in these specific game situations. We are an attacking team, how does the goalkeeper behave when we counter-attack? In situations of equal superiority, what does he do? Gets out of the goal? Stay in between the posts? He leaves the first post, he doesn't leave the post."* (Coach 1)

Whenever a head coach referred to the analysis of the collective and/or individual behaviours, we categorized them as "global dynamics". And, when confronted with the analysis of the "global dynamics" of the opponent teams, head coaches stated that they would focus attention on the situations they could take advantage of, and situations, which could present problems for their teams.

> *"I see how my opponents attack to know where and when I can win the ball to find out where it is and we can go out on the counterattack."* (Head coach 3)

> *"I focus more on their qualities, their best qualities, and their most serious defects to see if I can take advantage of them. It doesn't have to be in the counter-attacks, it doesn't have to be in the positional attack. Well, the goal is to find key points where you think you can win the game. (...) I try to look for their weaknesses, their collective and/or individual behaviours, which for one team can be mental and in another team can be about how they defend a certain game action."* (Head coach 4)

Similarly, with studies in football (Sarmento, Pereira, Matos, et al., 2013) and futsal (Sarmento et al., 2015) rink hockey head coaches have stated that they analyse technical, tactical, psychological and physical "characteristics of the players", searching for the individual weakness of the opponent players to explore.

> *"If in any player we find a detail that can be a weak point to take advantage of, we look for it."* (Head coach 4)

Contrary to futsal (Sarmento et al., 2015), rink hockey head coaches consider that they usually focus their attention on 5 moments: defensive organization; offensive organization; defensive transition; offensive transition, and; set pieces. Head coaches consider "set pieces" as both "period of inferiority" (disciplinary and temporary sanction which penalizes the teams whose representatives commit serious disciplinary offences; during this period, the penalised team has to have four players on the rink, including the goalkeeper) (World Skate, 2018) and particularly penalty and direct free-hit.

> *"Basically, we analyse the offensive process in all its modalities. Counterattack, positional attack, and period of inferiority. Some teams prefer direct play, whether or not they are outnumbered. The counterattack and its structure. And, finally, the defensive transition. What do we analyse: (1) the offensive model in all its variants; (2) defensive model in all its variants; (3) the offensive transitions; (4) defensive transitions; (5) and finally the set pieces."* (Head coach 1)

There were conflicting considerations between the interviewed head coaches concerning "statistical data" collection. Those who consider it important to collect statistical data have highlighted that they did collect data from their team and that the statistical data they had collected from the opponents refer to where the players most frequently had shot penalties and direct free-hits, and also the situations whereby goalkeepers had tended to concede more goals. However, although other head coaches consider that statistical data can be important, they believe that it is more important the qualitative analysis of the data. On the other hand, there are head coaches who have declared that they do not collect within-match data because they need themselves and the assistant coach to be focused on the game. If they consider it necessary to collect data, they do so *via* video analysis post-match.

It was highlighted that the "behaviour of the opponent coach" was analysed to understand the most frequent substitutions and to identify the tactical systems employed. Also, head coaches have observed the standard behaviour patterns of players regarding their usage of time during the game.

Why

We also tried to understand why head coaches deem it important to perform the analysis of the opponent teams. The main function of match analysis is to provide the coach with the necessary information about individual or collective performances (Carling, Reilly, & Williams, 2009). Rink hockey head coaches have reported that they performed the analysis of their opponent teams to predict and anticipate problems that could emerge during the game, seeking to exploit weaknesses and counteract strengths.

> *"What I look for with the analysis is that nothing surprises me. When a player starts a game, the worst that could happen is the uncertainty, it is not knowing what could occur. When you don't know, you can't predict, don't anticipate, everything surprises you. It is easier to be deceived. It's easier for them to beat you. If you have someone in front of you who knows what you are going to do, your life is much easier."* (Head coach 1)

> *"So that the players, when they are on the field, are watching a film that they have seen before and then manage to gain a few tenths of a second in decision making."* (Head coach 4)

Intervention

The "Intervention" in this instance is both the adaption of training exercises and a set of resources or techniques, which the head coach uses to effectively, transmit the information to the players (Figure 6.2).

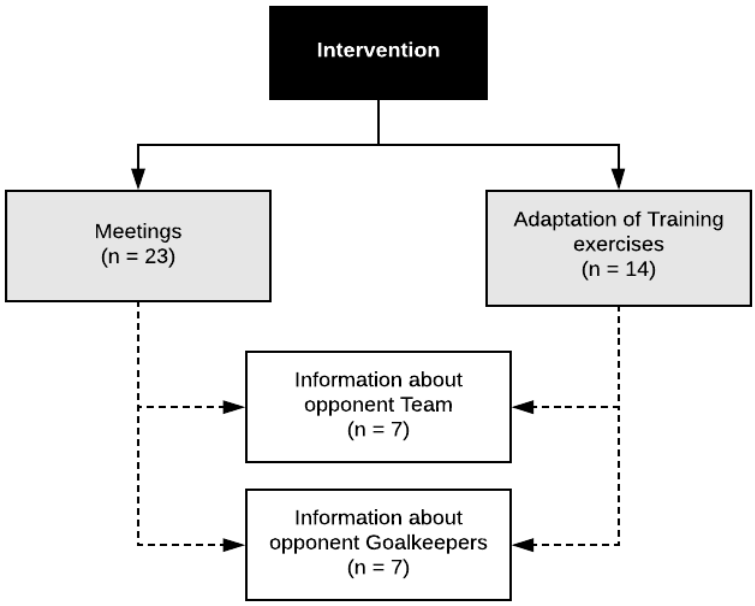

Figure 6.2 Graphical representation of the sub-categories for the category "Intervention". The number "n" reported represents the number of independent mentions of this idea/concept by the seven rink hockey coaches.

During the training micro-cycle, the intervention is sustained through the adaption of training exercises and meetings with the players.

Meetings

The number of meetings held to feedback video footage depends on the quality of the next opponent and can vary between 1 and 4 meetings per week. The time spent in meetings varies between head coaches (20 – 60 minutes) and the footage shown to

players does not exceed 15 minutes (8 – 15 minutes). Several authors have suggested that the use of audio-visuals tools enables coaches to have a more accurate and detailed analysis of the information (Groom & Cushion, 2004; Hughes & Franks, 2004; Liebermann & Franks, 2004).

> *"It always depends on the complexity of the opponent team. There are opponents that we can identify simpler processes and others that are more complicated to analyse, it has to do with the quality of the players and teams."* (Head coach 5)

> *"On average the video sessions don't take more than half an hour. But it is hard..."* (Head coach 1)

> *"(...) I prefer to distribute the video analysis it into 15, 12 and 10 minutes during the week and have the athletes focused on the information. We try to make the images we cut as short and objective as possible."* (Head coach 5)

Some coaches hold a meeting at the beginning of the week to analyse their previous performance, while others consider it unnecessary and choose to focus on the next opponent.

> *"I have meetings with the team to analyse our performance. (...) I sent everyone individual images of errors and successes. (...) In the meeting, we spoke only of situations seen in the collective analysis. In those meetings, we do not deal with individual themes."* (Head coach 1)

> *"In the meetings, we focus on our next opponent, we don't analyse what our performance was in the previous game. I can, in the summary of our last game, show one situation or another individually (...) a mistake made and which I think is important to analyse."* (Head coach 3)

The meetings essentially serve to analyse collective behaviour. If rink hockey head coaches feel the need, they hold individual meetings with the players to analyse individual performances.

> *"(...) if there are individual things to correct I, do it separately. Whether sending a simple cut of seconds by Whatsapp or speaking individually after training or 5 minutes before."* (Head coach 4)

> *"90% of our meetings are held in groups. When we think it is necessary, we talk to the players individually and show them videos. However, it is not very frequent."* (Head coach 5)

Adaptation of training exercises

During the training micro-cycle, the intervention is also sustained by the adaption of training exercises, depending on if it is based on the analysis performed on the opposing/own teams. This process should maintain the link between what was observed and the implementation of appropriate training sessions. This is in accordance with the coaching triad: game model; training model, and; analysis/evaluation model (Castelo, 2009).

> *"I often create an exercise from scratch to work out specific situations of our next opponent."* (Head coach 2)

> *"I program the micro-cycle training in function of what we have to correct individually/collectively and, the things that we have to be aware of or pay close attention to in the next game."* (Head coach 4)

> *"We adapt the week to the opponent and we choose 3 or 4 tactical exercises, which are never the same, depending on the next opponent."* (Head coach 5)

The information transmitted to the athletes should be carefully selected because too much information could lead to reduced focus (Hughes, Franks, Franks, & Dancs, 2019). Rink hockey head coaches have stated that they experience some caution with the quality and the amount of the information transmitted to the players through training exercises. For them is important that the players can retain the information which can be later used in a game.

> *"I try to pass on to the players the essential information that which we consider most important. If we give less information, we get the athlete to*

retain some of that information. Especially the most important. If we pass too much information, the athlete starts to process and may not catch what is most important." (Head coach 3)

"(...) we show them what the opposing team does, and also give them the best solution to counter that. (...) Otherwise the information is empty (...)" (Head coach 4)

"There is a preoccupation about how we pass the information to our players. In training we try to simulate situations to which we draw attention." (Head coach 6)

However, rink hockey head coaches disagree on the amount of the information to be transmitted to the athletes regarding the opposing goalkeeper.

"We try to pass all the information available from the opponent goalkeeper to our players. They need to know how he behaves, how he behaves in different situations. We have to pass a lot more information about the opponent goalkeeper than when we analyse the collective behaviours." (Head coach 3)

"I give players little information about the opponent goalkeeper, but objectively, so as not to overfill their chip, we also realize that the memory is short and gets full quickly, so we try to put the most important inputs." (Head coach 6)

The rink hockey goalkeeper

Due to the importance that head coaches permit to goalkeepers specifically, a more detailed understanding of this player's activity is presented according to three sub-categories: (1) specificities of the goalkeepers in rink hockey; (2) anthropometric profile, and (3) technique versus effectiveness (Figure 6.3).

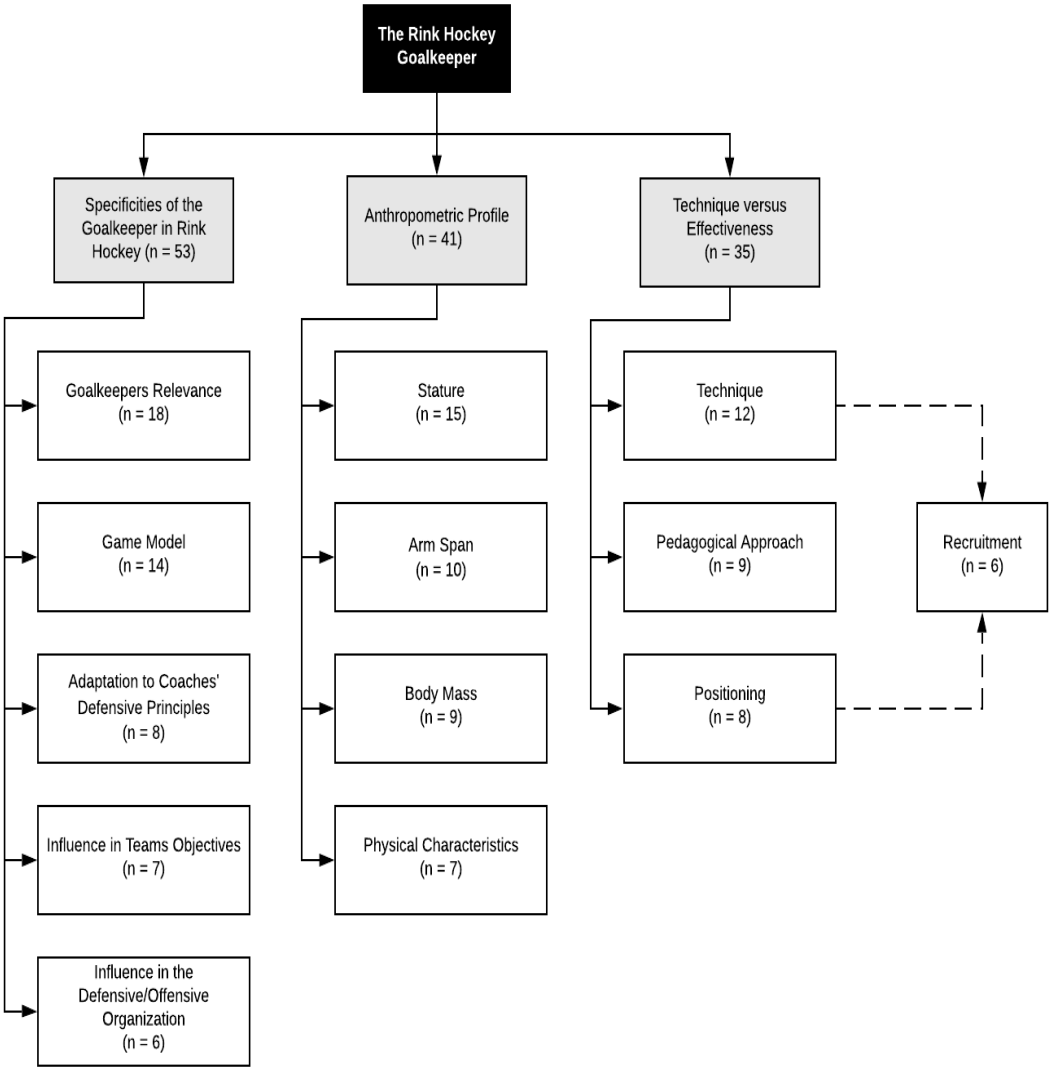

Figure 6.3 Graphical representation of the sub-categories for the category "The Rink Hockey Goalkeeper". The number "n" reported represents the number of independent mentions of this idea/concept by the seven rink hockey coaches.

All the interviewed head coaches consider that the goalkeeper is the most important player in a rink hockey team.

> *"It is a fundamental position of a team. We can vary in a slightly higher or lower percentage, but I think we all agree that it is a fundamental position."* (Head coach 4)

When questioned about the importance of rink hockey goalkeepers and their characteristics in the construction of the "game model" there are some head coaches

that identified that their game model has nothing to do with the characteristics of the goalkeeper (head coaches 1, 4 and 7). On the other hand, head coaches 2, 5 and 6 stated that their game model is adapted to the characteristics of their goalkeepers, while coach 3 stated that it is the goalkeeper that must adapt to the game model.

The interviewed head coaches consider that rink hockey goalkeepers are more likely to adapt to the head coach's defensive principles. Additionally, they attributed considerable importance to having a "quality" goalkeeper to achieve success. When head coaches address the theme of the influence of goalkeepers on the teams' sporting goals, they argue that to reach the top spots of the league table, they need to have goalkeepers who can make a difference by their individual quality.

> *"At the beginning of the season we always talk to the goalkeeper about the defensive principles we have defined for the team and we try to adjust with what the goalkeeper feels most comfortable with. But I think that goalkeepers today are trained to adapt easily to a style of play or game model, as we want to call it."* (Head coach 3)

Some head coaches declared that the influence of goalkeepers is higher in the defensive rather than in the offensive organization.

> *"(...) defensive transition issues are prepared according to the goalkeeper and what he wants. (...) Despite everything, we have our ideas, but then if the goalkeeper wants the 2x1 or 3x2 depending on whether in a certain area go more to the player of the ball, leave the second post, leave 1xGR or in the 3x2 in the middle distance in one of the corridors, I won't be saying no. I adapt my defensive principles, in some situations, to what goalkeepers think is best for them."* (Head coach 7)

Head coaches do not consider stature as being decisive in the recruitment of a goalkeeper. However, they consider that taller goalkeepers have greater advantages when compared to smaller goalkeepers and that the weight must be suitable for the stature. When questioned about the importance of arm span, head coaches argued that they didn't consider it a relevant factor when recruiting a goalkeeper, however, considering the goal technique adopted by some goalkeepers, they deemed that this

anthropometric characteristic could play an important role. As opposed to identifying physical characteristics, the interviewed head coaches consider that they first look for effective quality goalkeepers. They also account for psychological characteristics, such as character, and only afterwards do they analyse their physical characteristics. The head coaches attributed a high degree of importance to the following physical traits: agility, strength and elasticity.

> *"(...) goalkeepers with greater stature and greater arm span, associated with technical qualities and individual tactical qualities, are the best goalkeepers in the world. Goalkeepers, who are smaller in size and have the same technical and tactical skills, are not so good."* (Head coach 1)

Head coaches assumed that they seek a balance between technical quality and effectiveness. Head coaches mentioned that although they like technically advanced goalkeepers, though it is also important that the technique corresponds with a high degree of effectiveness. Head coaches declared that if they do not have a goalkeeping coach in their technical staff, they use video images to correct goalkeeping errors. However, if they have a goalkeeping coach, head coaches tend to allow corrections to be made by the goalkeeping coach, either through the presentation of video images, the creation of specific exercises or through conversations.

> *"I like to see a goalkeeper in the goal that is aesthetically beautiful. Now if he is aesthetically pleasing to the eye, he has a good technique, he has a good position, but then he is not effective we will not think of him. What we want is effectiveness."* (Head coach 2)

Interviewed head coaches considered that good positioning is more important than a good technique.

> *"The association between technique and positioning is ideal. The ideal will be dominating the two. Now if I have to choose between positioning and technique I'll choose positioning (...) Clearly when choosing a goalkeeper in the first place is effectiveness."* (Head coach 7)

6.5. Discussion

Rink hockey is still a sport where scientific studies are scarce when compared to other team sports. Regarding the rink hockey head coaches, studies that allow the perception of how coaches perform the tasks of preparation, collection and transmission of information collected to their athletes are still scarce. Therefore, this study has attempted to explore the perceptions of rink hockey head coaches concerning the analysis of the opponent/own team, intervention and adaption of training practices and the bespoke position of the rink hockey goalkeeper.

Contrary to what happens in football, where the head coaches assign the tasks of observing the opponent teams to a performance analyst or assistant coaches (Sarmento, Pereira et al., 2014), rink hockey head coaches, like futsal coaches (Sarmento et al., 2015) assume the task of analysing the opponents' team. However, and despite conducting the analysis of the opponents' team, they assign the analysis of the set pieces to the assistant coach or the performance analyst.

Like in football (Sarmento, Pereira et al., 2014; Groom & Cushion, 2004; Hughes & Franks, 2004; Liebermann & Franks, 2004; McGarry, 2009), the use of video is an important tool for performance analysis. Because of the congested calendar, head coaches are not always able to carry out live observations of their opponents, despite enabling the analysis of environmental factors, which are not always perceptible on video. Carling et al. (2009) believe that the use of video is an essential tool for performance analysis and it assists with evaluating and presenting information about performance in sport. Also, the use of video as an analysis tool will help coaches to improve players' performance in areas such as technical and tactical knowledge, critical thinking, decision-making and, consequently, in increasing the athletes' confidence in their abilities (Groom & Cushion, 2004). Potentially, due to differences in financial resources, the use of sophisticated software (e.g., Amisco, ProZone, GPS) which assists football teams with analysing match data (Carling, Bloomfield, Nelsen, & Reilly, 2008) and facilitates the analysis of performance during training and competition, are still scarce in rink hockey. To the best of our knowledge, in rink hockey, only one team in the World (F.C. Barcelona) uses a local positioning system

(WIMU PRO™, Realtrack Systems SL) in training and competition (Fernández, Novelles et al., 2020; Fernández, Varo, et al., 2020).

Taking into account all that has previously been stated, this is why video is an indispensable tool for rink hockey head coaches in the analysis of opponents/own team.

Sarmento and colleagues (2013) have suggested that football coaches observe at least two to six games of their opponents, to detect the most regular patterns of the opponents' play. Like the rink hockey head coaches in our study, football coaches consider it important to analyse a large number of games to collect the information required to improve their decision-making processes (Sarmento, Pereiraet al., 2014; Travassos, Davids, Araújo, & Esteves, 2013). Therefore, head coaches who are unable to attend matches regularly during a competitive season may be at a disadvantage to those who manage to analyse more opponent matches in-person.

One of the main tasks highlighted was the analysis of the opponent goalkeeper activity and weaknesses. In rink hockey, the goalkeeper is considered to assume the most important position of the team and the performance of the goalkeeper is associated with the success of the whole team (Trabal, 2016; Sousa, Sarmento, Harper, Valente-dos-Santos, & Vaz, 2018; Trabal, Daza, & Arboix-Alió, 2020; Trabal & Riera, 2020). In sports such as futsal and football, head coaches do not attribute much importance to the observation of the opponent goalkeeper (Sarmento et al., 2015; Sarmento, Pereira et al., 2014). However, in rink hockey, almost half of the offensive actions end with an attempt at goal (Ferreira, 2003). Additionally, due to the speed of the game and to the reduced number of field players, the goalkeepers are frequently involved with play (Sousa et al., 2020). Due to their constant involvement in key actions of the game, it is essential to exploit the goalkeeper's weaknesses so that the other teams can have attacking success. This is in line with the first, second and third part of the Interaction Performances Theory, which deals with specific sources of opposition effect and also that are opposing effects on sports performance (O'Donoghue, 2009a). The quality of the opponent goalkeeper may influence the outcome of a match.

Head coaches highlight the need to analyse the "global dynamics" of the opponents' team, as well as "characteristics of the players". In the "global dynamic" analysis of the opponent teams, head coaches seek to find qualities (i.e., strengths) and deficiencies (i.e., weaknesses) in the opponents' team and individual players. This analysis is based mainly on collective and/or individual behaviour, which in some cases can be psychological, physical, tactical or technical. Detecting these characteristics are important for the development of game strategies by coaches, similar to those observed in elite football (Carling, Reilly et al., 2009; Drust, Atkinson, & Reilly, 2007; Sarmento, Marcelino et al., 2014), handball (Prieto, Goméz et al., 2015) and futsal (Serrano et al., 2013; Agras, Ferragut, & Abraldes, 2016).

Rink hockey head coaches break the game into 5 moments: (1) defensive organization; (2) offensive organization; (3) defensive transition; (4) offensive transition, and (5) set pieces (e.g., direct free-hits, penalties, indirect free-hits, periods of inferiority). The analysis of the set pieces is very important since there has been a rule change in 2009 (World Skate, 2018). This involved a technical sanction (i.e., concede a direct free-hit) each time a team accumulates 10 fouls or five additional team fouls and the temporary expulsion of an offending player (i.e., period of inferiority), which has brought greater emphasis to these specific moments of the game. It has been previously identified that the probability of scoring a goal is higher after a break in play (e.g., penalty, direct free-hit, indirect free-hit) in comparison with situations of dynamic movements (e.g., interception, disarm, ball recovery; Sousa et al., 2020). Additionally, the probability of scoring a goal after a break in play is higher in situations of direct free-hits and penalties. This result is coherent with findings in football where huge amounts of the goal are scored as a consequence of set pieces (Gonzalez-Rodenas, Lopez-Bondia, Calabuig, Pérez-Turpin, & Aranda, 2015; Armatas, Yiannakos, & Sileloglou, 2007; Grant, Williams, Reilly, & Borrie, 1999). In handball (Prieto, Gómez, & Sampaio, 2015) and futsal (Sarmento et al., 2016), the importance of set pieces is also well documented.

To the best of our knowledge, no study has properly analysed the probability of scoring goals in the "periods of inferiority" in comparison with situations of dynamic movement in rink hockey. Therefore, most of what is known about "periods of inferiority" is derived from anecdotal observation, though it is well established within applied rink hockey, that these situations play a crucial part in determining the

outcome of a match. However, in handball Prieto, Gómez and Sampaio (2015) concluded that opposing teams take advantage of the numerical superiority to improve their scoring performance. This data can provide important information to rink hockey head coaches and performance analysts about the importance of knowing how to effectively exploit these moments of play in rink hockey.

Not all head coaches from our sample believe in the necessity to collect statistical data. In football, Carling, Williams, and Reilly (2005) considered it important that the head coaches made use of simple statistical data during the game, such as the number of passes failed, and the number of times the team entered the offensive third.

In our study, only one head coach has stated that it was important to collect statistical data, such as ball recovery and the number of ball losses (Head coach 5).

The interviewed head coaches were unanimous in considering that the analysis of opponent teams does allow them to identify the opponent teams' patterns of play, as such exploiting their weaknesses and nullifying their strengths. These findings are in line with the first part of the Interacting Performances Theory, which states that the performance is influenced by the particular opponent (O'Donoghue, 2009a). Similar conclusions were found in other teams sports, such as football and futsal, where coaches consider relevant the analysis of their opponents' teams' performance to identify their opponents' strengths and weaknesses (Sarmento et al., 2015; Sarmento, Pereira et al., 2014). Acknowledging the strengths and weaknesses of the opponents' teams will help players and teams to exploit the weaknesses of the opponents while taking advantage of their strengths (O'Donoghue, 2009a).

After analysing the opponents' team, head coaches select the most relevant information (i.e., strengths and weaknesses) and pass it onto their players. Head coaches' intervention during the micro-cycle mainly involves the adaptation of training exercises feedback to players *via* meetings where the information is communicated through video analysis. According to Castelo (2009), head coaches should apply the available information in appropriate training sessions and game strategies to improve performance. Training exercises are considered the best way to transmit information to players (Sarmento, Pereira et al., 2014). The use of video analysis to highlight the strengths and weaknesses of the opponents is beneficial

(Carling et al., 2005; Knudson & Morrison, 2002; Carling et al., 2008; Sarmento, Pereira et al., 2014). Therefore, using these combined methods, head coaches can improve individual and team performances (Groom & Cushion, 2004).

Despite the goalkeeper being considered the most important player in a rink hockey team (Sousa et al., 2018; Trabal, 2016), not all head coaches from our sample develop their game model while taking into consideration the characteristics of their goalkeepers. This may be why head coaches considered that it was very important to have a "quality" goalkeeper. Developing a game model that seeks to exploit or enhance the best qualities of the goalkeeper can optimize the team's performance and consequently increase team success. The interviewed head coaches stated that rink hockey goalkeepers tend to be capable of adapting to the head coach's defensive principles, and perhaps that's why only 42.8% of the interviewed coaches adapt their game model to the goalkeeper. Further research is required to assess the effectiveness of goalkeepers in response to different game models.

The head coaches in the present study considered it was most important that goalkeepers have a proficient technique. However, head coaches highlighted that a greater stature was a preferable physical trait, though this had to be combined with technical quality for the trait to be used effectively. Head coaches also consider it important that goalkeepers needed to have a body mass that is in proportion to the stature. However more than being aware of the physical characteristics of rink hockey goalkeepers, head coaches believe effectiveness, technical quality and good positioning in the goal are important. The whole process of reading and anticipating what the opponents intend to do when attacking the goal facilitates 90% of the goalkeeper's work.

Although the current study provides novel insights into the rink hockey head coaches' perspectives, our research does have some limitations. Specifically, the authors of this work did not video record the sessions with the head coaches. If the interview had been video recorded, it would have been possible to analyse both verbal and non-verbal communication. Also, it was not possible to verify if the answers given by the head coaches corresponded to what they do during the micro-cycle of training, or if their answers intended to give a good impression about their attitudes and beliefs.

6.6. Conclusion

It is through the processes of observation and analysis of the game that head coaches seek to obtain information that can yield benefits; not only to increase knowledge about the game but also to improve the quality of the team and individual player performance.

Rink hockey head coaches highlighted that they: (1) prefer to perform the analysis themselves, rather than delegate the role; (2) consider video analysis an important tool for the observation and analysis of their opponents; (3) focus on the opponents' goalkeeper analysis; (4) identify qualities and deficiencies in the opponents' team and individual players; (5) focus their analysis on five moments of the game (defensive organization; offensive organization; defensive transition; offensive transition, and; set pieces); (6) assess the strengths and weaknesses' of the opponents' teams, and adapt training exercises accordingly, while feeding back information through video analysis, and; (7) head coaches consider that it is important that rink hockey goalkeepers are effective, show technical quality and have good positional sense.

This study facilitates understanding of how rink hockey head coaches operate in an applied environment. These data have implications for rink hockey head coaches, performance analysts and goalkeeping coaches from both a performance and training practice perspective. Rink hockey goalkeepers may also benefit from these findings such that head coaches highlight the types of characteristics that they consider important. Future qualitative research should focus on the perspectives of rink hockey players and goalkeepers.

SECTION III

CHAPTER SEVEN: Final Considerations

7. Conclusion

Despite the growth of the research in recent years dedicated to rink hockey, the numbers of studies devoted to performance analysis are still scarce. Much of the existing studies were published before 2009, the year in which the rules of rink hockey suffered a significant reformulation. Additionally, some significant body of academic research has never been published in international scientific journals, limiting access to the knowledge produced in these studies by rink hockey coaches. The scarcity of theoretical and practical background limits access to information about the game, which can be useful to coaches and practitioners, leading them to resort to the knowledge of other sports with distinctive characteristics.

Most of the available studies have focused on quantitative indicators trough the analysis of the occurrence of particular performance indicators. In those studies, the collective behaviours are described according to the type of attack most frequently used by rink hockey teams, percentage of ball possession and type of finishing actions. Additionally, other studies sought to have described and explained the activity of players and goalkeepers and have also compared some competing performances.

Notwithstanding, the recognized relevance, which the goalkeeper has in the sporting success of rink hockey teams, falls short investigation about this specific position. The existing research is focused mainly on the specificity of the physical training, their activity profile during the game and also on the perception of the hockey community (e.g., fans, players, coaches) about the relevance, which a good goalkeeper has on teams' success. However, there exists a lack of information concerning goalkeepers' techniques and postures, anthropometric characteristics, and also how situational contexts influence their performance and how rink hockey head coaches perceive goalkeepers relevance.

The need to improve the training process and the preparation for the game leads us to seek to comprehend coaches' practical needs. Thus, it is essential to recognise how

research can help coaches to improve the tasks associated with the performance of players and teams. In this sense, it becomes essential to receive feedback from coaches to be able to provide scientific contextualized pieces of evidence, which would contribute to the developing of sports performance in rink hockey.

Taking into account the limitations mentioned above, this Thesis provides deeper insight into the anthropometric and activity profile of rink hockey goalkeepers, as well as the performance demands of the game. Thus, the purpose of this Thesis is to contribute to the advance on practical and theoretical understanding, along with the empirical evidence regarding the rink hockey goalkeeper, as well as the performance demands of the game.

The final considerations presented here incorporate the particular contributions of the five studies carried out. In the end, reflections on the possible implications for the practice domain are included, as well as suggestions for future investigations.

7.1. Match analysis

Considering the results obtained, it seems pertinent that coaches consider the need to choose better finishing situations, as well as to explore the attack time allowed by the rules of the game (45" timed by a "shot clock"). Yet, winning teams tend to perform more counter-attacks and fast-attacks in comparison to losing teams, who, surprisingly, perform more organized attacks. This may happen because, when winning, teams adopt a more defensive posture, seeking to exploit the opponents' offensive mistakes in order to create offensive situations.

Associated with the low effectiveness of the offensive process and the high number of shots at goal, there emerges an ability to recover the ball possession after a shot on goal. The players must be prepared to react quickly after a finishing action and to regain possession of the ball effectively, because regaining the ball possession in more offensive areas is related to increased effectiveness of the offensive process.

Rink hockey players perform more than one thousand actions per game, being that passing, and tackling are the most frequent actions. Players sprint, on average, 4% of game-time, being that they tend to sprint more frequently in the first half of the game.

However, 22% of the game-time is spent in high-intensity activities, which allows us to classify it as a high-intensity game.

Like in other team sports, there exists a decrement of the physical performance in the second half of the matches. In rink hockey, the external load demands are lower than outdoors sports, where players travel greater distances. However, it is necessary to develop more scientific knowledge about the physical demands in competition, as well as understanding how coaches can bring training exercises closer to the physical demands of the competition. Simulating game situations, through small-sided games and conditioned games, which involve competition between players, may help to approximate the intensity of training to that of competition. The use of monitors (such as GPS and heart rate sensors), which make it possible to quantify the external and the internal load of the players, will allow coaches and researchers to have a clearer view about what training exercises can approach the physical demands of the game, and, in this way, to be able to approximate the demands of training to the demands of competition.

Due to the relevance which rink hockey goalkeepers have on a team's success and to the fact that there is not an instrument which could analyse their activity in competition, we have developed and validated an observational instrument tool in this study, which seeks to help coaches and researchers in the tasks of observation and analysis of the activity of rink hockey goalkeepers.

To build this observational tool there was conducted a query to coaches and goalkeepers, allowing us to create a nomenclature for the different techniques of rink hockey goalkeepers. One of the main difficulties found in the construction of the observational instruments had to do with different terminologies used for the same technique. Therefore, it was necessary to ask coaches and goalkeepers to standardise the terminology of the seven techniques presented to them and also the type of position those techniques represented.

So, for coaches, “knee on the floor” and “squatting” corresponded to a “basic position”. That “spatula” and a “side fall” corresponded to an “emergency position”. Regarding “fleck”, coaches considered that this technique could be defined as a

"position of expectation", and also as an "optimum position" and/or "emergency position".

This observational instrument proved to be a very useful tool for coaches to analyse not only the offensive performance of the teams, but also to relate to the contextual situations with the performance of both the teams and the goalkeepers. Also, it may also have been helpful to collect data providing useful information to coaches in the improvement of goalkeepers' techniques.

7.2. The rink hockey goalkeeper

Rink hockey goalkeepers of different competitive levels are characterized by different anthropometrical profiles. International goalkeepers are taller, have lower values of subcutaneous adiposity compared to non-international goalkeepers and compete in a higher volume of games. Rink hockey goalkeepers must perform dynamic movements and maintain postural stability, whilst restricted by a protective gear and in a crouched position. Fat mass may have a major impact on mobility, postural stability and performance of rink hockey goalkeepers. Higher levels of training and competition are correlated with reduced body fat percentage and, perhaps, the differences between groups could be a consequence of that. Although there is no scientific evidence to explain how the stature can influence the performance, rink hockey coaches consider that goalkeepers who combine great stature with good technique are usually better at performing their duties. This could have important implications for scouts, regarding the selection process and coaches who work with players on developing performance. Since there are differences between international and non-international goalkeepers with regard to body fat, coaches should develop individualized specific training programmes to properly enhance the physical performance of goalkeepers and educational programmes to increase rink hockey goalkeepers and coaches knowledge about basic nutrition.

Also, based on our data, we have concluded that international goalkeepers tend to be taller than non-international goalkeepers, thus specific talent identification programmes should be developed to identify and select young athletes with higher

stature. The use of scientifically grounded methods (such as the Khamis-Roche Method) can give a reasonably accurate idea of how tall a child will become.

Additionally, we have concluded that the performance of rink hockey goalkeepers is influenced by the opposition's offensive play.

The effectiveness of rink hockey goalkeepers is influenced by tactical and situational variables and is related to the half of the match. The decline in the effectiveness of goalkeepers in the second half of the matches may be associated with a decrease in physical condition, as well as to rule changes. A considerable change to the rules was made to the game in 2009, which involved a technical sanction (i.e., it conceded a direct free-hit) each time a team accumulated 10 fouls or 5 additional team fouls. The application of this rule has resulted in more direct free-hits in the second half of matches, potentially as a result of physical and mental fatigue-related fouling.

Furthermore, we have concluded that goalkeepers are less effective when having to deal with direct free-hits and penalties (set pieces) in comparison to situations of indirect free-hit. The combination of these two variables (rule change and physical capacity), associated with reduced effectiveness saving direct-free hits, may help to explain the decrement in effectiveness from the first to the second half of the game.

Also, the goalkeeper's performance is always influenced by the match status. Whenever a team is losing, they tend to take more risks and, as a consequence, they are exposed to defensive counter-attacks. By assuming a more offensive approach and by becoming more exposed to a dynamic counter-attacking play, the teams will often encounter situations of numerical disadvantage. Coaches must prepare the teams (including the goalkeepers) to be able to deal with this overload from a tactical and technical standpoint to limit the opposition space and to delay the attacks.

Tactical and situational variables may also influence goalkeepers' performance. The results of our study have indicated that the effectiveness of the goalkeeper is reduced when the opponent team regains the ball possession in areas near the goal, when the last interaction is made in those areas and the final shot is placed in the upper zones of the goal.

Since goalkeepers' performance is influenced by tactical and situational variables, rink hockey coaches should prepare technically and tactically their teams to limit the opposition space and delay attacks. Also, and due to the reduced effectiveness of the goalkeepers when the opponent team regain ball possession in areas near to the goal, when the last interaction is made in those areas and the final shot is placed in the upper zones of the goal, coaches should develop strategies to regain ball possession in areas near to the opponent goal. At the same time, after identifying the threat of those actions, coaches must create ways to get out of opponent pressing, whether through tactical actions or through developing the goalkeepers' ability to distribute the ball effectively into the desired areas.

The most frequent technique used, and the most successful method of shot-stopping is the "knee on the floor". Moreover, we have found that the "fleck" technique was ineffective in our study. The specific goalkeepers' training should be focused on the conception of new training strategies to improve the goalkeepers' performance. To this end, it would be essential for rink hockey head coaches to have someone with specific knowledge of the position (e.g., goalkeeper coach), so that they can enhance the physical, technical, tactical and psychological abilities of the goalkeeper. The rink hockey goalkeepers play a key role in teams' success. However, their specific training remains largely neglected. Therefore, the specific rink hockey goalkeepers' training may include can be working on saving set pieces, distributing the ball into opposition areas and performing the most effective techniques.

The understanding of the fragilities of the general rink hockey goalkeepers may assist coaches in exploiting their weaknesses by manipulating them through quick movements, passes and placing the ball in the upper section of the goal.

7.3. The perceptions of rink hockey coaches

In this Thesis, we have performed semi-structured interviews to explore the perceptions of rink hockey coaches of the tasks of preparation/observation of the opponent's/their own team, the interventions and the adaptation of training practices, as well as the bespoke position of the rink hockey goalkeeper. The use of semi-

structured interviews revealed to have an enormous potential in getting rink hockey coaches to explaining how they prepare their teams for competition.

In general, rink hockey coaches prefer to analyse the opponents themselves to plan the training strategies, as well as to assist with tactical preparation and implementation of within-match strategies. For them, the analysis of opponents' teams allows them to identify patterns of play, so exploiting their weaknesses and nullifying their strengths.

They consider video analysis an important tool to analyse the opponents' strengths and weaknesses, with particular focus on the opponents' goalkeeper. One of the reasons why coaches consider video an essential tool for performance analysis has to do with the lack of financial resources. Also, and due to a congested calendar, most of the times, coaches are not able to carry out live observations of their opponents.

The analysis of the interviews which we have carried out have allowed us to conclude that coaches like to analyse a large number of matches, paying attention to specific situational aspects, game moments (such as the defensive and the offensive organization, the defensive and the offensive transitions, the set pieces) and the goalkeeper. Coaches have highlighted that one of the main tasks of observation is the analysis of the opponent's goalkeeper's activities, especially, their weaknesses.

The training intervention involves the adaption of training exercises, whereby information is communicated during meetings. Coaches seek to communicate the information, which they consider to be most relevant without giving too many details. Not all of the interviewed coaches have developed their game model in a way to exploit or enhance the best qualities of the goalkeeper. However, they all agreed that it is very important to have a goalkeeper who can optimise the team's performance and increase success. For rink hockey coaches' effectiveness, technical quality and a good positional sense are the most important characteristics of a rink hockey goalkeeper.

The understanding of how rink hockey coaches operate in an applied environment has implications both on performance and training practice perspective. The thoughts of the interviewed coaches focused on the idea that assuming the tasks of observation of

the opponents' teams would help them to outline the strategies and the training plans to effectively prepare the team and the players for the competition, aiming their analysis at five different moments of the game, identifying qualities and deficiencies in the opponents' teams and players.

Due to the relevance of rink hockey goalkeepers in teams' success, coaches consider it important to analyse them, seeking to identify the weaknesses to exploit. After assembling the information about the opponents' teams, players and goalkeepers, coaches select the most relevant information to share with the players through the adaptation of training exercises and *via* meetings where the information is communicated through video analysis.

The knowledge of the tasks of preparation/observation and training intervention may constitute a starting point for a systematic training process in a dynamic perspective of the interaction between them.

7.4. Future research directions

Based on the analysis of some options taken during our research, the interpretation and direction of the results and some of the limitations inherent to the study, we hereby would like to suggest some developments for future studies.

Further research is needed to expand the findings of this Thesis, to develop a deeper understanding of the rink hockey goalkeeper, the performance demands of the game and the perceptions of the rink hockey head coaches. As such, future research should aim at a longitudinal analysis to understand the implications of the changes in the rules of the game and what they have contributed to the evolution of the game.

It would definitely be useful to perform a more detailed analysis of the activity profile of the players and the goalkeepers, to have a more holistic view of the physical, technical, tactical and psychological demands of the game according to situational variables (such as quality of opposition, match half, game location).

It would also be interesting to conduct a more detailed analysis of the effectiveness of the offensive process of the rink hockey teams and of how this effectiveness is influenced by the momentary result.

On the other hand, the detection of patterns of the play within rink hockey teams using networks and/or sequential patterns, could be a fruitful path in this area, since, in its detection, the time factor, which is extremely important in the context of this game, is taken into account. Additionally, it would be profiting to develop studies, which do not only take into consideration the team in the possession of the ball, but also focus on the team in the defensive process. It would also be interesting to analyse the movement of the players and goalkeepers off the ball.

Lastly, future qualitative research should focus on the perspectives of rink hockey players and goalkeepers' coaches' interventions in competition and training.

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