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Willian Roque Ferrari

THE OFFENSIVE PROCESS OF THE HIGH PERFORMANCE IN HANDBALL GAME:

STUDY FOCUSED ON THE ANALYSIS OF THE OFFENSIVE PERFORMANCE OF FINALIST´S TEAMS OF THE EUROPEAN CLUB

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

December of 2020

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Abstract

Verifying an apparent lack of articles related to the analysis of the handball game at club level, the aim of this study was to analyze the offensive process between the professional teams participating in the final of the Champions League of the European Handball Federation, the EHFCL, we tried to investigate the reasons why not all of them reached the same level of performance on their course.

In the first moment a description is made of the main studies related to the sport and the methodologies used in the process of game analysis, to identify the most used variables within the offensive process, giving the necessary theoretical framework, thus being exposed in chapter 1 and 2 where more than an introduction also a systematic review of the literature that collaborate to support the objectives outlined in the thesis.

In the following chapter (3) our study aims to develop and validate an instrument of observation of the offensive process within the context of handball As a result of the research, handball coaches considered the following macro-categories, referring to the following indicators: 1) Offensive actions: Positional Attack, Fast Attack and Counter Attack; 2) Shooting indicators: 9 meters, between 9 and 6 meters, 6 meters and 7 meters; 3) Collective Actions: Type - I, Type - II, Type - III and 4) Field zones. Based on the results obtained the observation system covers all the fundamental aspects of the game and as such can be used for the collection and processing of information for a long-term analysis of the different variables of the offensive process in the handball game, the instrument confirmed appropriate levels of intra and inter observer reliability.

When proceeding to chapter 4 of the research aiming to analyze the differences related to the offensive process between winning and losing teams participating in the European Handball Federation Champions League (EHFCL), the results established that the winning teams performed better regarding the variables that defined the effectiveness of offensive shots, especially successful positional attacks and fast attacks and also obtained a higher number of assists by the winning teams.

Chapter 5 examined the influence of tactical and situational variables on offensive sequences during handball games, The results revealed that positional attacks and fast

attacks decreased the probability of success of an offensive sequence by 66% and 54% when compared to counterattacks, Compared to offensive sequences where the shooting is performed from the 9M zone, the chances of an offensive sequence ending successfully are 3.65 and 3.60 times higher, for offensive sequences where the shooting is performed from 7m and 6m.

The last study to be presented in chapter 6 aims to show the evolution of the finalist teams in 5 years of the EHF Champions League, the results show 21 linear tendency lines valid for the study. The winning teams showed five increasing lines (positive slope) and 16 decreasing lines (negative slope) during the competition showing their evolution throughout the competition from the quarterfinals to the final, because of the increasing difficulty expected in successive matches, the tendency lines tend to show a decreasing slope as one progresses to the final. However, the winning teams show greater regularity in adapting to the increasing challenge, describing growth in some key indicators.

Finally in chapter 7 displays a generalized conclusion of all the studies and contextualized within handball and mainly its practical applications for the development of the sport, emphasizing the main characteristics and profiles of winning teams within the main handball club competition. Creating new models for data collection and analysis, for coaches and researchers from the conception of performance as well as training.

Keywords: Handball Analysis; Offensive Efficiency; Winning Teams; Offensive Analysis; Linear Tendencies.

Resumo

Ao verificarmos uma aparente escassez de artigos relacionados com a análise do jogo de andebol ao nível de clubes, o objetivo deste estudo foi analisar o processo ofensivo entre as equipas profissionais participantes na final da Liga dos Campeões da Federação Europeia de Andebol, a EHFCL, procuramos investigar as razões, pelas quais, nem todos alcançaram o mesmo nível de rendimento no seu percurso.

No primeiro momento é feita uma descrição dos principais estudos relacionados na modalidade e as metodologias utilizadas no processo de análise de jogo, para assim identificamos dentro do processo ofensivo as variáveis mais utilizadas, dando o enquadramento teórico necessário, sendo assim expostos no capítulo 1 e 2 onde mais do que uma introdução também uma revisão sistemática da literatura que colaboram de apoio aos objetivos delineados na tese.

No capítulo seguinte (3) nosso estudo visa desenvolver e validar um instrumento de observação do processo ofensivo dentro do contexto do andebol Como resultado da investigação, os treinadores de andebol consideraram as seguintes macrocategorias, referindo-se aos seguintes indicadores: 1) Acções ofensivas: Ataque Posicional, Ataque Rápido e Contra-Ataque; 2) Indicadores de disparo: 9 metros, entre 9 e 6 metros, 6 metros e 7 metros; 3) Acções Colectivas: Tipo - I, Tipo - II, Tipo - III e 4) Zonas de campo. Com base nos resultados obtidos o sistema de observação cobre todos os aspectos fundamentais do jogo e como tal pode ser utilizado para a recolha e processamento da informação para uma análise a longo prazo das diferentes variáveis do processo ofensivo no jogo de andebol, o instrumento confirmou níveis apropriados de fiabilidade intra e inter observador.

Avançamos assim para o capítulo 4 da investigação com objetivo de analisar as diferenças relacionadas com o processo ofensivo entre equipas vencedoras e vencidas participantes na Liga dos Campeões da Federação Europeia de Andebol (EHFCL), os resultados estabeleceram que as equipas vencedoras tiveram um melhor desempenho em relação às variáveis que definiram a eficácia dos remates ofensivos, especialmente ataques bem sucedidos posicionados e ataques rápidos e obtiveram também um maior número de

assistências por parte das equipas vencedoras.

No capitulo 5 examinou-se a influência de variáveis tácticas e situacionais em sequências ofensivas durante jogos de andebol, Os resultados revelaram que ataques posicionais e ataques rápidos diminuíram a probabilidade de sucesso de uma sequência ofensiva em 66% e 54% quando comparada com os contra-ataques, Em comparação com sequências ofensivas onde o remate é efetuado a partir da zona de 9M, as hipóteses de uma sequência ofensiva terminar com sucesso são 3,65 e 3,60 vezes superiores, para sequências ofensivas onde o remate é efetuado a partir dos 7m e 6m.

O último estudo a ser apresentado no capítulo 6 visa mostrar a evolução das equipas finalistas em 5 anos da Liga dos Campeões da EHF, os resultados mostram 21 linhas de tendência linear válidas para o estudo. As equipas vencedoras apresentaram cinco linhas crescentes (inclinação positiva) e 16 linhas decrescentes (inclinação negativa) durante a competição mostrando a sua evolução ao longo da competição desde os quartas-de-final até à final, devido à dificuldade crescente esperada em jogos sucessivos, as linhas de tendência tendem a apresentar uma inclinação decrescente à medida que se avança para a final. No entanto, as equipas vencedoras se mostram uma maior regularidade ao se adaptar ao desafio crescente, descrevendo o crescimento em alguns indicadores-chave.

Por fim no capítulo 7 exibe uma conclusão generalizada de todos os estudos e contextualizadas no âmbito do andebol e principalmente as suas aplicações práticas para o desenvolver da modalidade, destacando os principais características e perfis de equipas vencedoras dentro da principal competição de clubes de andebol. Criando modelos para recolha e análise de dados, para treinadores e investigadores desde a conceção da performance como também do treino.

Palavras-chave: Análise em Andebol; Eficácia Ofensiva; Equipas Vencedoras; Análise Ofensivas; Tendencias Lineares.

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Introduction

Chapter I

General introduction

Chapter 1. General introduction

1.1 Introductory note

This chapter aims to present an overview of handball in particular and game analysis in collective sports in general. In this sense, the literature described below during this chapter comes as a support base for the guiding question of this study:

- *How is the analysis of the offensive process of teams that have accomplished the success of their actions and their competitive stages?*

With the technological advancement, numerous and varied means and methods are now available to coaches and researchers, through game analysis, to access information and to increase knowledge about their sports and improve the quality of performance of both players and teams (Garganta, 2001; Long & Nelson, 2013).

Support for a multi-level approach to game analysis is provided in the following sections.

Given the above, the purpose of this study is to analyze the offensive process among professional teams participating in the final of European Handball Federation Champions League.

1.2 Game Observation and Analysis

The analysis of the game is an important tool for the knowledge of the team itself and for the development of the correct strategy for confrontation with opponents. This instrument also allows us to have a clear view of the behaviour of a team during a match and determine its possibility in the game (Garganta, 2009).

Furthermore, the notational analysis is a methodology that allows to create a relevant information from video analysis of the competition, adopting pre-established criteria (see Clemente, Couceiro, Martins, Figueiredo, & Mendes, 2014). However, the most used expression in literature is game analysis (Dimitrios, 2019; Saavedra, Þorgeirsson, Chang, Kristjánsdóttir, & García-Hermoso, 2018), considering that it includes different phases of the process, namely: i) observation of games and ii) data notation and their interpretation (Berg & Lune, 2001).

On the other hand, dynamic analysis is based on the game data. Therefore, tactical actions are recorded by video in sequential and chronological order, providing a more complete and expanded view of the game, this analysis allows us to identify the factors that influence the performance of a team (Prieto, 2015).

From another perspective, time-movement analysis has become more popular mainly in high-level sport. This point of view has brought benefits to professionals involved with the teams, allowing the monitoring of the physical performance and the maintenance of high levels of performance throughout the game and during the season (Carling & Bloomfield, 2013). Consequently, the automatic tracking systems allow an analysis that determines the essential variables to the physical performance of athletes (e.g., races, sprints, jumps, distances covered, speed, heart rate, among others) (Buchheit, 2014), supporting the planning of the training process and the preparation of the teams for games (Granados, Izquierdo, Ibanez, Ruesta, & Gorostiaga, 2008).

The identification and measurement of dynamic interactions between moving objects have become an active area of research, being defined as the way in which the movements of two individuals are related in general context, such as the game (Macdonald, Ball, & Hough, 1980; Schmidt, Lee, Winstein, Wulf, & Zelaznik, 2018) or the interdependence in the movements of two individuals (Clemente, Martins, & Mendes, 2016; Steenbergen, Van Der Kamp, Verneau, Jongbloed-Pereboom, & Masters, 2010), where it refers to the same general idea, to identify how the movements of an individual are related to each other.

All this type of analysis methodology is intended to lead to a more objective discovery of team performance during competition and the ability to identify factors that influence individual and collective performance (Cloes, Bavier, & Piéron, 2001). So, controlling the team's behaviour and tactical options is a complex process, based on constant readjustments of team's performance and the evolution of the competitive situation (Sampaio & Janeira, 2003).

In conclusion, for a correct evaluation, it is necessary to understand the patterns of behaviour that emerge in the various game situations (Seabra, 2010). This point may be particularly important in the study of game analysis. Therefore, the relationship between the different levels of analysis can be a key point for a deep understanding of the game processes developed during the competition in team sports and especially in handball.

1.3. Collective Sports Games (CSG) Analysis

There is a number of sports, called collective sports games, that have in common the following characteristics: i) existence of an object (e.g., ball, disc), which can be played by the player either with the hand, foot or by means of an instrument; ii) a standardized playing field, which limits the players' action; iii) a target to attack or defend (goalpost, basket); iv) the companions who cooperating, help the progression of the ball, and v) opponents whose opposition must be overcome and the existence of a regulation which must be respected (Gréhaigne, Richard, & Griffin, 2005; Prudente, 2006).

The process of analysis in Collective Sports Games (CSG) constituted the elements of sport performance in the tactical-situational context (Morales, 2007). It can thus be considered that it should give the individual the possibility to take critical, reflexive, intelligent and creative appropriation of the skills and abilities of the sport through activities aimed at the elaboration of clear technical and tactical concepts that can be applied in the context of a game situation.

Acero and Peñas (2005) consider that the analysis of sports performance in the CSG, integrated in the training process, serves to determine actual values of effectiveness, and allows evaluate players and team strengths and weaknesses in relevant performance factors, such as, control the success of team and players training. However, the recognition of the importance of tactical dimension in the contribution of players and teams in CSGs had a decisive influence on the modification of the way game analysis has been approached in recent years.

In this sense, studies carried out in the scientific area, regarding Handball, are similar to other collective sports, such as Football (Aquino et al., 2016; Kempe & Memmert, 2018), Basketball (Blake, 2015; Schwesig et al., 2018) and other collective sports (Campos et al., 2015; Perez, Ordonez, & Gonzalez, 2018; Valhondo, Fernandez-Echeverria, Gonzalez-Silva, Claver, & Moreno, 2018; Vaz, Mouchet, Carreras, & Morente, 2011) have increasingly used the analysis of the game as a mean to achieve greater knowledge of performance in collective sports, considering different indicators: i) morphological, ii) motor, iii) psychological and iv) mainly technical-tactical.

1.4 Handball

Handball is considered a collective invasion sport, played by two teams that display an opposing relationship, with an intermittent characteristic, which alternates periods of effort and recovery, in a compound of sub-maximal incentives with incomplete periods of pause, where the intensity of effort oscillates according to the position of the player on the field (Povoas et al., 2014).

The handball game is defined by six moments. The first, consists of the change from defence to attack. The second moment is to attack the opponent. Usually this movement is fast, with two or three passes. In the third moment, the speed of the game moves in an ascending line seeking to maintain the high rhythm and intensity of the previous phases, against a yet to be organized defence. In the fourth moment, the organized (position) attack finds an organized defence.

The fifth moment, which restarts the defensive activity, must be attentive and try to recover the possession of the ball during the return and to prevent the opponent from taking advantage of the imbalance of the defensive organization. In the sixth and final moment, the defence is organized and tries to prevent the opponents from having a good chance of reaching the goal. If this prevention is successful, the defence team returns to the first phase (Romero & Greco, 2012).

In the process of the game of handball, players make moves and trajectories with their teammates and facing their opponents. Thus, a system of interrelationships is developed, which leads to the need of a permanent use of actions in an intelligent way and a variability of game situations (Lenzen, Theunissen, & Cloes, 2009; Medina, 2003). The game takes place in a context subjected to instability and uncertainty, and where repeated appeals to the athletes decision-making abilities emerge due to problems that arise during the game that have multiple choices (Freitas, 2005; Ribeiro & Volossovitch, 2004). In this way, what is decisive in the final success of each individual or collective action is the adaptation to the condition of the moment of the game, that is, the individual tactical quality of the players and the collective tactics of the team (Aquino García, 1989; Gréhaigne et al., 2005)

1.5 Handball Observation and Analysis

In this section, we discuss about the processes of analysis of the game of handball. Initially, the first studies of observation in handball were intended to perceive the performance of the teams based on the characteristics of their players, such as, height, weight, spread and body index, making a combination between the players and their positions on the field, seeking to find correlations between these variables and the performance, as well as the final classification in competitions (Prudente, 2006) .

In fact, by 2012, on the Web of Science databases (1900 a 2012) e MEDLINE (1950 to 2012) by Prieto, Gómez, and Sampaio (2015), could be founded studies that included 373 articles with "handball" as the main subject. However, Saavedra (2018) updated this research with scientific work published from 2013 to 2018 in journals indexed in the Web of Science, and new 256 articles were found, evidencing the growing scientific interest in this sport, including 32 articles (12.69%) about performance and indicators of success in the game, which has been the second theme with more publications in the last 5 years. Within these two kinds of research, the physical abilities and physical condition of athletes is the term with the most significant number of publications.

Given the above, research in this field of game analysis has led to a vigorous investigation into all aspects of the game, such as: i) Team game pattern; ii) Tendencies in the evolution of the game; iii) Performance analysis and iv) Offensive process in Handball.

1.5.1 Tendencies in the evolution of the handball game

To understand the evolution over the years of the structure, organization and development in handball, it is necessary to guide the studies on the game standards offered by the high-level handball games; observe and analyse the method of playing during successive years of championships in various periods and their significance, reflect and analyse the patterns that contributed to the evolution of the game that is appreciated today.

Román (2015) defines the evolution of handball in several moments during history. Hence, the beginning of the modern game (1972-1980) is marked in the handball by the recovery of the status of Olympic sport and its incorporation in the return to the program of the Olympic Games of Munich 72. This was a great importance for the growth

of this sport in the media level, designing the beginning of of handball as one of the great sports of the federation. New Alternatives (1980-1990) is the time when handball emerges in some countries, such as the evolution of the Union of Soviet Socialist Republics (USSR) and Spain. At the same time, it maintains as the high level Eastern European countries and a new regulation that begins with the application of progressive sanctions in 1981. However, the last decade of the twentieth century (1992/2000) is considered "golden" in the evolution of the game with the creation of the European Handball Federation (EHF), the creation of the European Championships and new competitions in different categories. In the 21st century, faced with a panorama of strong competition with other sports, clubs, federations and institutions that take care of this sport should combine efforts so that the improving project of handball continues to grow. The conception of the evolution of the game is vast, but the tactical bases remain, and we must distinguish in the analysis of historical perspective what differs between the fundamental and the accessory, the permanent and the temporary.

The constant evolution of the game brings a new perspective on rules, especially the advanced goalkeeper rule being established, this succeeded a game strategy increasingly used in handball. With this change in mind, there is a preference for teams to use the advanced goalkeeper in the 10 final minutes of play and in moments of numerical inferiority from a punishment and indicates a tendency in the moments when the team is at a disadvantage in the game result (Musa et al., 2017).

In a more modern perspective of the tendencies and evolution of the teams, Alexandru and Acsinte (2017) emphasize the evolution in the competition and how an international conception of the game and of the training adapts to the specificity of the teams. Determining the frequency of the opportunity to score in the European Championship 2010 and comparing it with the one registered in the 2008 edition, they verified an increasing of goal opportunities after a certain period of time, evidencing the development of the tendencies in handball game.

Also, for a period of two years, Gryko, Bodasiński, Bodasińska, and Zieliński (2018) have analysed the efficiency of offensive actions in positional attack and defensive actions by handball players participating in two consecutive World Handball Championships (Spain 2013 and Qatar 2015). In 2013, there was a change in the concept of the game in the positional attack and, in 2015, there was an increase in the number of actions that resulted in shots on the six meters area of the opponent's goal and a more

aggressive game by the defensive players, with the European teams always having an advantage over teams from other continents regarding the efficiency of technical and tactical actions.

Finally, considering the influence that these changes on rules had on the evolution of the game in the last decade and, especially, in the first years of the 21st century, we should not close the circle to possible changes that affect the whole universe and to elements that condition the structures of attacking systems, developing into a more spectacular game.

1.5.2 Pattern of handball Game

The game pattern in handball is considered as the set of collective actions that a certain team repeatedly makes, game after game, therefore a game pattern can be established. Therefore, identifying patterns of play at different levels is not easy because it requires thorough observations of the same game or several games of the same team. It is essential to know how to systematize and precisely evaluate the patterns of play that are justified in a particular style of a team or player, adjusted to the reality of the moment of the game. It is important to distinguish in which moment those fragments of the game, that later create a pattern, style or solid tactical bases standing in teams and players occur (Román, 2015).

Having a good knowledge of the overall team and player model only is not enough to guide coaches. They should also know how the best teams adapt the game design and how the teams that compete in the national tournaments adapt to the design of the international match. Rodríguez and Anguera (2018) identify the Spanish team that played in the world cup, in 2015, and find found the main influence for the center-back role in the game pattern of the team, thus confirming the existence of different patterns of play. Those same patterns depend on the characteristics of the player who occupies the center-back position and show the differences in each player and the importance of the individual characteristics and skills in the actions that are first perceived and later executed.

The strategy to create a pattern of the handball game represents an important component of the team's tactics and players in the conception of the game and training that has its peculiarities of adaptation or ways to execute. The location of matches can explain the emergence of regularities or specific patterns of game. Pic (2018), through an observational methodology, shows the existence of game patterns according to the

location of the match and elaborated guidelines that may help the training work, thus identifying as differences in behavioural patterns between home games and away games in handball matches. Finally, on a more individual context, Santos et al. (2009) make a study related to analysing pivot performance by getting as much information as possible about the whole activity and identifying sequential patterns of players behaviour's and game using sequential analysis.

1.5.3 Performance in handball matches

Researchers of different sports have pursued to understand differences in the performance of players and teams in order to identify the factors that significantly determine the effectiveness of individual, group and collective tactical actions (Argilaga & Anguera, 1999; Janelle & Hillman, 2003). The analyses of the games are aimed at determining the individual performance of athletes, general conditioning, techniques and tactical skills of the teams while evaluating the overall and individual performance of the opposing teams (Vuleta, Milanović, Sertić, & Jukić, 2000).

It is observed that the interpretation of evolutionary analysis situated at the level of the game has in fact had huge impact by emerging the necessity to analyse competitions and to associate this knowledge with sporting success (Sampaio & Janeira, 2001). The success of handball performance is described as an analysis of the main performance indicators, is a combination of indicators of attack, defence and goalkeeper that in turn can adequately predict the success of a team in a game (Daza, Andrés, & Tarragó, 2017).

Saavedra, Þorgeirsson, Kristjánsdóttir, Chang, and Halldórsson (2017) seek to discover this success of sports performance comparing statistics related to handball games by results of games in winning and losing teams and identifying characteristics that discriminate the performance of handball. Thus, showing that the differences in shots, assists, goalkeeper saves, and fast attack help coaches to improve these game indicators.

With similar research, Milanović, Vuleta, and Ohnjec (2018) determine the performance indicators of winning and losing teams at the 2012 Olympic Games, with the winning teams being the best on the variables that defined the effectiveness of offensive performance, especially the successful performance of counter-attacks. They also had greater efficiency in attacking actions, with a strict selection of distance shots and goal shots, as well as more assists and ball interception.

Karastergios, Skandalis, Zapartidis, and Hatzimanouil (2017) determine and

explain the differences between winning and losing handball teams according to the indicators of offensive errors and turnovers, being the defensive actions, turnovers, and general performance of the goalkeeper the main factors that separate the winners from the losers in women's matches between equal opponents.

The purpose of Konstantinos, Elissavet, Panagiotis, Ioannis, and Konstantinos (2018) is to evaluate the effectiveness of specific performance indicators at different competitive levels. An attempt was made to represent what measured the performance indicators by examining the influence of that performance in the game. The most critical parameters in the final classification of the men's teams are the gaming experience and the influence the anthropometric index. As to women's teams, the indexes that affected the final classification, in order of importance, are the performance efficiency, indices of game experience and the efficiency of team shots.

Another factor of performance indicator of the teams that can be measured is the significant role played by goalkeepers in handball. In the coaches community, it is recognized that the goalkeeper performance can predict the classification of teams (Hansen et al., 2017). A significant relationship was identified between the goalkeeper's save statistics and the team's final standings. Defensive efficiency is essential for teams to achieve a higher rating and therefore selecting and training the goalkeeper require more than just assessing physical abilities.

Moreover, one of the most important factors of success in the performance of the teams is the influence of the coaches on the game itself. Gomes, Volossovitch, and Ferreira (2018) studied the significant effect of timeouts on three performance indicators of the teams - defensive and offensive effectiveness and their current result. The results of this study do not allow us to differentiate the coach's intervention and the effect of the timeouts on the result but associate the content of the coach's intervention with the consequences of timeouts in different competitive contexts. Besides, the relationship between timeout requests in specific contexts and the prediction of the final result of the games can also be a challenge of the research in game analysis.

1.5.4 Offensive process in handball

The offensive process in general allows the team to know when to perform specific movements. So, *how will the team take the ball to the attack and how will it try to shoot the goal?* The importance of coordinating each of the phases of the offensive process is

significant because each phase depends on the other phases for the success of the team, having as final target the goal.

A team initiates the offensive process from the time it has the possession of the ball and ends this process when it does not have ball possession, through shots, ball stealing by the opposing team or turnover. Over the last few years and as a result of recent rules, handball has evolved into a high-speed game, with goal attempts transposing to a significant factor influencing the result of the game (Yiannakos, 2016).

Román (2015) observes that with increasing speed, the number of attacks increases, decreasing their duration, making the importance of the "phase of organization of the attack" diluted and the third force of counter-attack has joined the attack "execution phase" by increasing the number of shots near the opposing area.

When comparing male and female handball, Onsalo Damboriena (2018) analysed that the differences of the offensive collective game were obtained from 1244 offensive actions, being 543 actions with women and 701 with men. Although the difference in the total number of actions exhibits more similarities than differences in the collective offensive strategies employed by both, it is believed that women play much more tactically, causing long attacks in pursuit the 6 meters shooting. Currently, women's handball has significantly evolved in tactical, physical, and technical aspects, confirming that it can be as spectacular as men´s.

Leuciuc and Dariusz (2018) make a descriptive analysis of the offensive process in EHFCL, and in a general context of the game. Each attack lasted less than 30 seconds, with 483 attacks, which means 120 attacks per game; 251 goals were scored, with averages of 62 per game, of this total of 251 goals scored, 215 were scored in positional attack and 36 on counter-attack. The counter-attack number of goals represent less than 15% of total goals, indicating that the main pattern of team play is related to organized attack.

Determining the differences in situational activity indicators from the offensive process between winning and losing teams in elite male handball is the main goal of Bajgorić, Rogulj, Čavala, and Burger (2017). The differences in situational activity indicators of the offensive process were determined using a set of 21 variables in which success in handball was determined primarily by a large number of rapid attacks against disorganized defences and by the efficient conduct of attacks against organized defence.

Being the shot at goal the most crucial factor for handball and sports success,

Yiannakos (2016) intended to evaluate the shots accomplished according to the total number of offensive attempts, the offensive formation adopted, the positioning of the finisher, the location of the ball inside the goal and its effectiveness of shots. The study reveals a difference between shots performed in different positions within the court since most of them are started in the less-occupied areas of the opponent's defenders, and the effectiveness of the shot depends equally on the quality of the preparation performed during the training sessions and the space left by the opponent's defence to perform the goal attempts.

A fact greatly studied by the scientific community in game analysis is the counter-attack. Being an indicator of success in the offensive process, authors Ruiz Sánchez, Gómez-López, and Herrera Cuadrado (2017), with the purpose of analysing the effectiveness of counter-attack in high-performance teams, state that there is a high effectiveness in counter-attack shots.

The teams tend to have a higher number of shots during the counter-attack phase of the first half of the game. Another important factor is that almost every shoot occurs in suspension. The central area of the field is where the highest number of shots occur, and most shots are made at a distance of less than 6 meters.

1.6. Relevance of the study

The importance of handball as a sport is recognized not only by the large means it moves but also by its sports and educational interest, which gives him priority status in several programs and institutions within Europe, notably in the East and Nordic countries. The mapping of the offensive variables presented is not an enclosed issue, but rather an important marker for future analyses (qualitative and/or quantitative) based, mainly on the opinion of experienced researchers and trainers. Therefore, other variables can be presented as a priority to the analyses and their relevance may be directly related to the level of the teams or the categories that will be analysed.

Due to the lack of studies to fill in the scope of the handball game analysis, the general objectives of this study are:

1. *Organize the literature on the studies made out on the topic of analysing the offensive process of handball.*

2. *Add new variables necessary for game analysis making the study more complete.*
3. *Identify a major handball club competition and the most balanced competitive instant.*
4. *Studying the coaches' perception of game analysis and its practical virtues.*

In order to develop a reliable characterization of the offensive process in handball and to be able to estimate the attack patterns and relate them to the effectiveness of the team's attack, the improvement of handball game analysis contributed to the characterization of the offensive process of the game and collected knowledge about the determinants of success/failure in this particular sport.

This study conducts an analysis of the offensive process of the best handball clubs in Europe that are participants of the EHF Champions League. Evaluating the best club championship becomes relevant in order to define an offensive game pattern that can be followed by coaches of high-performance teams, aiming at a better performance of their teams and athletes.

After selecting teams and participants from different countries, we propose to study not only the development of the sport and the excellence in a specific group of teams that reached a high level of income, but also the reasons why not all of them reached the same level of efficiency in its course. The results of the present research obtained during five years of this competition will be compared and can constitute relevant references for the development of handball, seeking to provide information for all those who intend to lead their teams to reach higher levels of performance.

A few problems were identified during the research of the present study and the following questions remain to be explored:

1. *Analysing the main games of handball clubs, is there a possibility to differentiate between winners and losers? For instance, in which variables are the teams most distinguished?*
2. *As to the teams' performance, is it possible to identify the game variables that indicate a successful offensive process?*

3. *Is there a tendency in the winning teams regarding the pattern of games analyzed that correspond to their success and non-success during the competition?*

1.7. Handball match analysis: a systematic and dynamic approach

The purpose of this thesis was to understand the processes underlying game analysis in handball. Different studies, on different levels of organization, have been described, ranging from individual to collective. A collection of five original research articles, submitted or published in periodicals, constitute the main body of this thesis. Each article was presented as an individual chapter following the format requested by the journal to which it was submitted.

The current chapter (Chapter 1) introduces the general conceptual and scientific foundations that support the handball game analysis research program.

Chapter 2 presents a *Match Analysis in Handball: A systematic review* of the literature in correspondent analysis in adult male handball. The review will be performed according to the PRISMA (Preferred Reporting Item for Systematic Reviews and Meta-Analyses) guidelines. In total, 28 articles received further in depth reading and analysis for the systematic review. After in-depth analysis, it was decided that the most appropriate way to present the results would be to categorize, creating a categorization system according to levels of analysis: a first-order level, depending on the type of analysis performed (descriptive, comparative analysis and productivity); and a second-order level, depending on the type of variables analysed.

In Chapter 3, a methodological article entitled *Development and validation of an instrument of observation of handball game* was presented. The variables of the offensive process targeted by this study were defined based on a questionnaire previously sent to the Portugal Handball Federation and handball associations. It was fundamental to elaborate a method of observation through categories systems based on the bibliographical research carried out and the data collected in the exploratory phase. This is the result of a process of construction and validation of an observation instrument that allows a reliable record of behaviour and interactions of the players and teams through the analysis of the actions and sequential patterns in the offensive part of the one high-performance game in handball.

Chapter 4 presents an experimental research article entitled *Comparative analysis*

of the offensive effectiveness in winner and losing handball teams. This work investigated the problem of ball possession, a factor of great importance in the definition of a set of situations occurred throughout the game, also examining the situations of shooting in handball. Our purpose is to determine the differences between winning and losing teams throughout the offensive process of the teams, to use notational analysis and game videos to identify the whole process.

Chapter 5 introduces another experimental research article entitled *The Influence of Tactical and Situational Variables on Offensive Sequences during Elite Handball Matches*. It examines the influence of tactical and situational variables on offensive sequences during handball matches and tries understanding how contextual factors influence in performance of the game. To provide a more comprehensive and generalized view of modern tactics in handball and its effectiveness associated with the goal.

Chapter 6 addresses the study *Offensive analysis of handball games: Comparative tendencies of evolution between the winning teams of the EHF CL*. This study followed a different research strategy, a comparative analysis of the offensive behaviour and the pattern playing of the teams, based on the tendencies lines of the variables that identify the winners, demonstrating its offensive consistency through performance indicators.

Finally, Chapter 7: presents a comprises the general discussion in which the findings of the various studies are summarized and put into context and their implications discussed, theoretical and methodological considerations as well as practical applications.

Chapter II

A systematic review

Chapter II

Review Paper

Match Analysis in Handball: Systematic Review

Chapter 2. Match Analysis in Handball: Systematic Review

Reference: *Ferrari, W., Sarmento, H., & Vaz, V. (2019). Match analysis in Handball: A systematic review. Montenegrin Journal of Sports Science and Medicine, 8(2), 63-76. doi: 10.26773/mjssm.190909*

2.1 Abstract

The main objective of this research is to focus on a systematic review of the literature on handball, to identify potential areas for future research in this specific area of specialization. The most common research topics were identified, their methodologies were described, and the evolutionary tendencies of this area of research were systematized. Within a systematic review of the Web of Science ™ Core Collection, PubMed, and SportDiscus databases, according to the PRISMA guidelines, the following keywords were used: "handball", each one associated with the terms: "match analysis", "performance analysis", "notational analysis", "game analysis", "tactical analysis", and "patterns of play". Of the 245 studies initially identified, 28 were fully reviewed, and their results were analysed. Studies that meet all the inclusion criteria were organized according to the research design as descriptive, comparative, or predictive. The results showed that most of the studies use the statistics available through the tournament organization; some researchers have attempted to find some association between cause and effect in different contexts. The studies focused their analysis on four main variables of performance: total shots and finals, end match outcome, Time Outs (TTos), and the relationship between home advantage. This systematic review can provide useful information on potential lines of research for performance analysts in the field of handball match analysis.

KEYWORDS: Game Analysis; Performance; Teams' Sports; PRISMA.

2.2 Introduction

Handball is one of the most popular team sports in the world (Clanton & Dwight, 1996). There are six confederations and 209 affiliated countries to the IHF (International Handball Federation), with approximately 795,000 teams and 19 million players. The rising popularity of handball is aligned with a significant increase in the number of related scientific publications.

The systematic observation of the handball matches, and posterior analysis of the results is referenced at the beginning of the 1970s. The French Handball Federation and a group of students from the Sports School of Cologne (Germany) observed the matches of the World Championship of 1970 and became pioneers in the observation and analysis of the match of handball (Kunst-Ghermanescu, 1976). Following several authors (Alonso, 1994; Antón García, 1992; Brčić, Viskić-Štalec, & Jaklinović-Fressl, 1997; Czerwinski, 1998; Taborsky, 2000; Vuleta, Milanović, Sertić, & Jukić, 2000) engaged in similar studies related to performance factors and how they influence team performance and the final score in the competitions.

Nowadays, match analysis has become a subject of great interest of the performance in team sports, such as handball (Silva et al., 2016; Silva, 2008; Valeria et al., 2017; Zapardiel Cortés, Ferragut Fiol, Manchado, Abraldes Valeiras, & Vila Suárez, 2017), football (Kempe & Memmert, 2018; McKenna, Cowan, Stevenson, & Baker, 2018; Yang, Leicht, Lago, & Gómez, 2018), basketball (Clemente, Gonzalez-Villora, Delextrat, Martins, & Vicedo, 2017; Conte, Favero, Niederhausen, Capranica, & Tessitore, 2017) and other sports (Kempton, Sirotic, & Coutts, 2017; Sarmento et al., 2016; Valhondo, Fernandez-Echeverria, Gonzalez-Silva, Claver, & Moreno, 2018).

An essential factor in all sports (handball) performance is the impact that coaches have on the player's development. In this sense, performance analysis is one of the main subjects of movement and training sciences. Match analysis methods used in this field have gradually improved, and many of the most popular and original recent studies (Debanne, 2018; Dello Iacono et al., 2018; Ferrari, Vaz, Sousa, Couceiro, & Dias, 2018) in this area have involved recording performance variables during or after competitions and visual and written storage of these records using computers. When examining the literature of handball, most of the research done on this subject focuses on the

physiological problems or injuries of the athletes. There are many articles in this area in comparison to match analysis (Prieto, Gómez, & Sampaio, 2015b).

The exponential growth in the number of studies about performance observation analysis and success indicators in several sports has prompted literature review studies seeking to synthesize the principal results and research methodologies of different sports, including football (Sarmento, Anguera, Pereira, & Araújo, 2018; Sarmento et al., 2014), volleyball (Miguel Silva, Marcelino, Lacerda, & João, 2016), futsal (Agras, Ferragut, & Abraldes, 2016) and basketball (Courel-Ibáñez, McRobert, Toro, & Vélez, 2017). However, there is no such specific study done in this way that synthesizes the main results of observation and analysis of matches in a sport as popular as handball.

Thus, the main goal of this study was to review and organize the literature around match analysis in handball, so to understand the topics of more developed research in this area, their methodologies, and the tendency of evolution for future projects.

2.3 Methods

2.3.1 Search Strategy: Databases, Inclusion Criteria and Process of Selection

A systematic review of the available literature was conducted according to PRISMA (Preferred Reporting Items for Systematic reviews and Meta-analysis) guidelines. The electronic databases Web of Science ™ Core Collection, PubMed, and SportDiscus were researched for relevant publications prior to the 8 of January 2019 using the keywords "handball", each one associated with the terms: "match analysis"," performance analysis", "notational analysis", "game analysis", "tactical analysis", and "patterns of play".

The inclusion criteria for these articles were: i) contain relevant data concerning technical and tactical evaluation or statistical compilation, and time-motion analysis; ii) performed by amateur and/or professional adult male handball players and iii) written in the English language.

Studies were excluded if they: i) included children or adolescents; ii) included females; iii) did not include relevant data for this study, and iv) were conference abstracts. If there was disagreement amongst authors regarding the inclusion of certain articles, a discussion was held until a consensus was found.

Two independent reviewers (WF, HS) independently screened citations and abstracts to

identify articles potentially meeting the inclusion criteria. For those articles, full-text versions were retrieved and independently screened by two reviewers to determine whether they met the inclusion criteria. Disagreements about whether the inclusion criteria were met were resolved through discussion with the other authors (VV).

2.3.2 Extraction of Data

A data extraction sheet (adapted from the Cochrane Consumers and Communication Review Group's data extraction template) was developed and tested with ten randomly selected studies. First, one researcher extracted the data from included studies and then, a second researcher checked the extracted data. Disagreements were resolved by consensus (WF, HS).

2.4 Results

2.4.1 Search, Selection and Inclusion of Publications

The initial search identified 245 titles in the described database. These data were then exported to reference manager software (EndNote X8), and any duplicates (59 references) were eliminated automatically. The remaining 186 articles were then screened according to the title and abstract for relevance, resulting in another 57 studies being eliminated from the database. The full text of the remaining 129 articles was then read, and another 101 were rejected due to a lack of relevance to the purpose of this study. At the end of the screening procedure, 28 articles received further in-depth reading and analysis for the systematic review (Figure 2.1).

After in-depth analysis, it was decided that the most appropriate way to present the results would be to categorize them as suggested (Sarmento et al., 2018), creating a categorization system according to two levels of analysis: a first-order level, depending on the type of analysis performed (descriptive, comparative analysis and predictivity, and a second-order level, depending on the type of variables analysed (Figure 2.2).

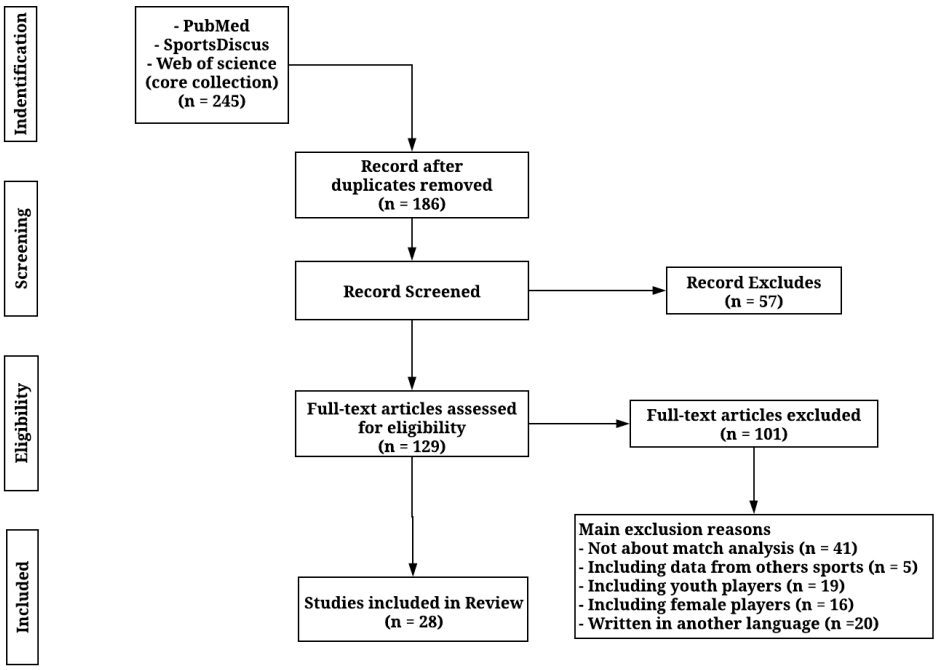

Figure 2.1. Preferred report items for systematic review flow diagram

2.4.2 Major Research Topics

After in-depth analysis, it was decided that the most appropriate way to present the results would be to categorise them according to their subjects of: (1) descriptive analysis; (2) comparative analysis – Defensive analysis, playing position, game results; (3) contextual variables – game location, Time out; (4) Predictive analysis – Score a goal; Game result.

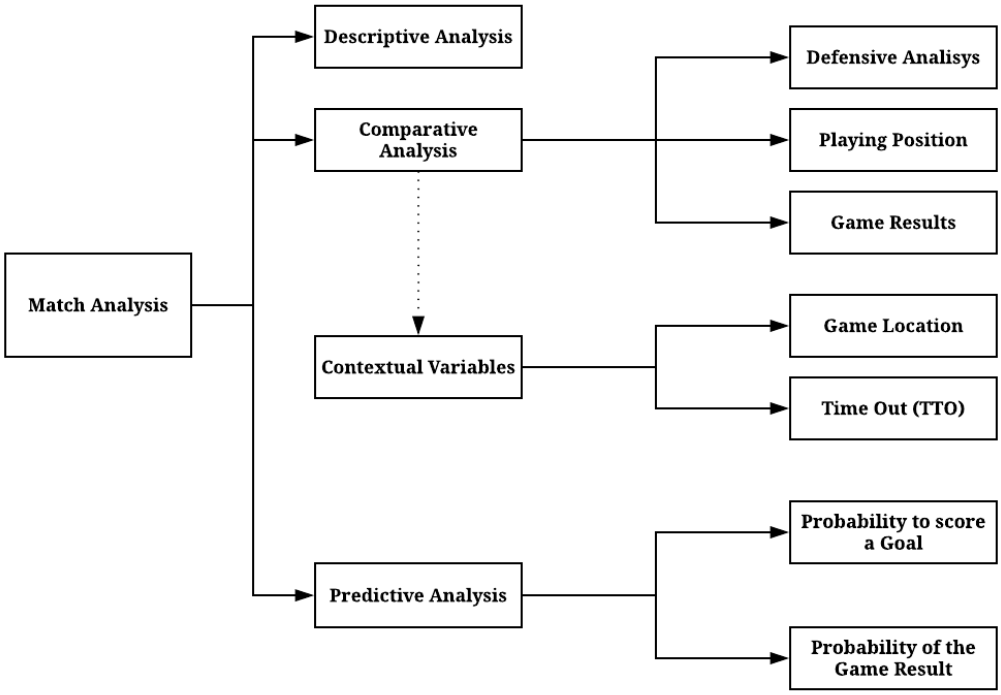

Figure 2.2. Scopes of match analysis

2.4.3 Descriptive Analysis

The performance variables during or after the competitions are the main topics that other authors approach (Bilge, 2012; Gutiérrez, Rojas, Ortega, Campos, & Parraga, 2011) with their written and visual storage, being the measurement and evaluation of the athletes' performance and having an important role in planning the training and competition process (Table 2.1).

Table 2.1. Studies with descriptive analysis

Study	Sample	Results	Variables
Gutiérrez et al. (2011)	11 men took part in this study, seven Goalkeeper for handball team and four field players.	The goalkeepers moved in the correct direction of the throw in 91.1+9.4% in situation TM2. In situation TM4, the goalkeepers made errors on 17.5+7.6% occasions (N=95) and managed to save the ball on 66.3+7.5%	The time of play; the speed of the ball; the accuracy of the throw; speed of lateral movement; speed of lateral movement and distance travelled at the time of release of ball; speed of vertical movement and distance travelled 100ms before the launch of ball; speed of vertical displacement and distance travelled at the time of release of ball; maximum speed of the vertical component during the period of anticipation; transverse acceleration of the goalkeeper In situation TM2 the thrower made the perpendicular throw on goal with only two possibilities for the direction of the throw: the upper and lower corners of the goal on the same side as the throwing arm. In situation TM4 the thrower could throw at each of the four corners of the goal.
Bilge (2012)	72 matches -Olympic Games 2004 and 2008; -World Championship 2005, 2007 and 2009; -European Championship of 2004, 2006, 2008 and 2010.	Average number of fast break goals per match was higher in OG and WC than in the EC. Fast break efficiency rates were higher in OG and WC than in the EC. The ratio of pivot position goals and fast break goals to all goals in OG and WC was higher than in EC The ratio of back court position goals and break-through goals to all goals in OG and WC was lower than in the EC.	Average number of attacks, attack efficiency, counter-attack efficiency, goalkeeper effectiveness per match, average number of disqualifications and foul per match, and differences in players by position

2.4.4 Comparative Analysis

Based on comparative studies, five topics were created to better understand the subject: Comparative analysis based on Timeouts (TTos), (Gomes, Volossovitch, & Ferreira, 2014; Gutiérrez Aguilar, Montoya, Fernandez, & Saavedra, 2016; Guzmán, Calpe-Gomez, Grijalbo Santamaria, & Imfeld Burkhard, 2012; Prieto, Gómez, Volossovitch, & Sampaio, 2016) (Table 2.2).

Table 2.2. Empirical studies predominantly with comparative analysis based on Time Outs (TTOs)

Study	Sample	Statistical procedure	Variables
Guzmán et al. (2012)	1 Match in Spanish League.	Chi - person and comparison.	Implementation of the action technical tactics, a result of the actions and technical tactics, intensity, behaviour is not specified, organization of the team, the decision of the arbitrator; and the "type of behaviour", composed by feedback positive, negative, orderly instruction, encouragement, disagreement, I am sorry, consultation, call, suggested instruction, in request to timeout, aggression or insult and alert.
Gomes et al. (2014)	2178 TTOs in - 720 matches in Spanish League in seasons; 2009/2010, 2010/2011, 2011/2012.	Analysis of cluster k-means The Pearson chi-square test	Goals scored and goals during allowed as last five possessions of each team before the call of the TTo. The match was classified in six episodes of 10 minutes each. The location of the match included two categories - home and away
Gutiérrez Aguilar et al. (2016)	558 TTo applied: - The European Championship of 2012, Serbia (156). - World Championship 2013, Spain (346); - 2012 Olympic Games, London (76).	The Wilcoxon tests The contingency coefficient and V of Cramer. The test of Mann-Whitney Test.	The end result of departure final difference (number of goals), differences in the score when requesting TTo, in favour of the team that applies a time limit, the difference in the score five minutes before the minute the TTo is requested, the modification of the defence system, substitutions of players and completion of five previous attacks and subsequent to the time at which the TTo is requested
Prieto et al. (2016)	64, 10% of TTOs (total) in 240 matches in Spanish league.	Cluster Analysis of k-means; Logistic regression of the linear model.	The number of goals scored before and after each TTO, a ball was defined as a unit for analysis of temporal effects, the goals scored for the periods within the TTo and previous post first, third and fifth possessions of ball were recorded, the difference between the goals scored and awarded to a ball before the TTo and draw a ball after him, as differences in the goals recorded five poses of ball before the TTo and five represents the ball after the TTo.

Regarding comparative analysis based on home advantage, the data processed allowed us to identify those critical game-related statistics that are affected by playing at home or away and how these variables might be affected depending on the particular context of the match according to team ability of both teams (Gomez, Lago-Penas, Viano, & Gonzalez-Garcia, 2014; Gutiérrez Aguilar, Fernández, & Saavedra, 2014; Lago-Penas, Gomez, Viano, Gonzalez-Garcia, & Fernandez-Villarino, 2013; Oliveira, Gómez, & Sampaio, 2012; Pic, 2018) (Table 2.3).

Table 2.3. Empirical studies predominantly with comparative analysis based on home advantage

Study	Sample	Statistical procedure	Variables
Oliveira et al. (2012)	480 matches in the Spanish League seasons; 2007/2008, 2008/2009.	ANOVA	Efficacy of 6-meter, 7-meter and 9-meter shots and counter-attacks
Lago-Penas et al. (2013)	240 matches in the Spanish League during a season 2012/13	Test of Mann-Whitnney	Effectiveness and goals from 6-9m, Effectiveness and goals from attack, full and speedy effectiveness to trim the field; assists, Errors, yellow cards, suspension of 2 minutes, blocks, theft of ball, effectiveness of the networks in shoot of 6-9m, effectiveness of the networks in counter-attack, and overall effectiveness of the networks.
Gomez et al. (2014)	365 matches Olympic Games (12), European Championship (9) between 1936 and 2011.	Tests of Wilcoxon Test of Mann-Whitney U The Kruskal-Wallis Test	The number of matches won, the number of matches won, the number of matches lost, the number of goals scored and allowed, the number of goals scored and allowed in a match, the sex of competitors and the league involved.
Gutiérrez Aguilar et al. (2014)	240 games in the Spanish League a season 2012/13	Kaiser-Meyer-Olkin As analysis of cluster of K-means Post-hoc Scheffé and Bonferroni correction.	The Factor 1 (success of 6m and 7m, shots and 6m, 7m and 9m of shots without success); Factor 2 (6m and 9m of shots and bailouts succeed without success from shots 9m); Factor 3 (successful and unsuccessful), shots of counter-attack, assists and balls retrieved blocks); Factor 4 (successful and unsuccessful shots of 7m); Factor 5 (bailouts successful and unsuccessful shots of counter-attack); Factor 6 (cards

Krawczyk (2015)	50 matches EHF Champions League 2012-2013.	The non-parametric Wilcoxon test	Errors of spend, 24 and dribble the ball; errors in decision-making, started with the ball; enters the goal when penalized; Absences offensive; errors resulting from exclusion from the match; passive match; and a shortage resulting in a shot of penalty being awarded to the opponent
Pic (2018)	39 matches 14 Spanish League 14 German Bundesliga 11 French League	T-pattern Multivariate analyses	Location; Final result; Scoreboard evolution; Zone; Attack; Defending; Time Observer

This review was to determine the key indicators of discrimination in a comparative analysis between winners and losers. (Foreti, Rogulj, & Papi, 2013; Gutiérrez Aguilar & Ruiz, 2013; Rogulj, 2000; Skarbalius, Pukėnas, & Vidūnaitė, 2013) (Table 2.4).

Table 2.4. Empirical studies with predominantly comparative analysis based on winners and losers

Study	**Sample**	**Statistical procedure**	**Variables**
Rogulj (2000)	Total of 80 matches, the World Championship 1999, in Egypt.	ANOVA	Number of goals scored, attack, counter-attack and quick attack and goals, goals, shots and goals from 6-meters (tips excluded), goals and shots in first line, trim and goals of tips, trim and goals from penalty 7-meters, assistance, errors, punishment of 2 minutes, stealing the ball, blocks shots defended by networks of 6-meters, tips, first line, a penalty of 6-meters, counter-attack, quick attack.
Foreti et al. (2013)	101 matches in the World Championship handball in Croatia in 2009	ANOVA Kruskal-Wallis test. Correlation coefficient of Spearman	For the construction of the model, we analyse the total of 47 indicators of situational activity on its players, being 16 in position to attack, attack of transition in 7, 9 in defence of a position in defence of transition 5 and 10 indicators of situational activity of the player Activity indicators of situational attack from a defensive position, transition, transition defence, guard trans In the early stages of the match offset activity indicators were situational analysed within 6

			positions in positional attack
Gutiérrez Aguilar and Ruiz (2013)	Matches of the 24 teams of the world championship in Sweden - 2011.	Data Envelopment Analysis	Goals and shot from different distances (6-meters, 6-meters, 6-meters), situations (fast attack, counter-attack and organized attack)
Skarbalius et al. (2013)	5 European Championships of Handball Sweden 2002 Slovenia (2004), ´ Switzerland (2006), Norway (2008), Austria (2010).	ANOVA Test of Tukey's post hoc	Attacks, shooting, effectiveness of guard networks, positive actions (theft, flight of 6-meters gain, blocked shots) and negative actions (2 minutes suspension)

The following studies present indication related to other comparative analyses among several indicators in a handball match analysis. (Fasold & Redlich, 2018; Gryko, Bodasiński, Bodasińska, & Zieliński, 2018; Hatzimanouil, Giatsis, Kepesidou, Kanioglou, & Loizos, 2017; Meletakos & Bayios, 2010; Meletakos, Vagenas, & Bayios, 2011; Prieto, Gómez, & Sampaio, 2015a; Prudente, Sousa, Sequeira, Lopez-Lopez, & Hernandez-Mendo, 2017) (Table 2.5).

Table 2.5. Empirical studies predominantly with comparative analysis

Study	Sample	Statistical procedure	Variables
Meletakos and Bayios (2010)	10.358 final scores of seven national championships in Europe;	Post-hoc tests The k-means clustering Chi-square tests	The first group included all matches with a difference in goal two or less. These matches were categorized as matches closed, while all other matches were categorized as open matches
Meletakos et al. (2011)	288 matches in 3 World Championships.	MANOVA Univariate F-tests	Shot at 6-meters from the pivot, shot from the wings, shots at 6-meters by first-line players, 7-meter penalty shots, counter-attack, fast attack, percentage of shots and effectiveness.
Prieto et al. (2015a)	60 matches, 280 exclusions, in Spanish league, season 2011-2012	-Analysis of linear and multiple logistic Analysis of cluster k-means	Match status, location, quality of opposition, and match situational variables were incorporated in the analysis
Hatzimanouil et al. (2017)	44 matches, League of Greece seasons 2013-2014, 2014-2015.	The Kruskal-Wallis test. Mann Whitney U Test.	Compare the differences between playing six positions (left side, left, center, right player attacking player, the right wing and the player in line) about places out, goals and saves

Prudente et al. (2017)	16 matches, European Championship 2012 preliminary phase (8) the final stage (8)	Technical Analysis of polar coordinates.	The table included as main criteria, organized defence, type of defence, the match time, score, specific positions, tactical and result of the action, from which were developed systems of category and each indicator set, covering in detail, the actions and behaviours that can occur in these situations the match
Gryko et al. (2018)	World Championships 2013 Spain (84) 2015 Qatar (88)	One-way ANOVA	Number of actions recorded, and efficiency of actions and the offensive and defensive actions taken by field players and goalkeepers
Fasold and Redlich (2018)	1000 actions in 55 matches, Germany 1st League (24), 2nd league (21), 3rd league (10), Season 15/16	Barnard's unconditional test	Foul, cards, time-suspension followed by a penalty, signal for passive play, goal, technical mistake missed shot blocks, interceptions, offence and defence outcomes were categorized into goal and no goal actions

2.4.5 Predictive Analysis

The common goal of this type of studies is to determine more efficient ways to play. Through the use of qualitative multidimensional data instead of unidimensional data, the ability to describe the handball match is enhanced (Debanne, Laffaye, & Trouilloud, 2018; Dumangane, Rosati, & Volossovitch, 2009; Gruić, Vuleta, & Milanović, 2006; Rogulj, Srhoj, & Srhoj, 2004; Srhoj, Rogulj, & Katić, 2001) (Table 2.6).

Table 2.6. Empirical studies with predominantly predictive analysis

Study	Sample	Statistical procedure	Variables
Srhoj et al. (2001)	80 matches World Championship in Egypt 1999	Regressive Analysis	Number of goals and shots of goal position; of seven meters; of the pivot position; of the players of 1º line; individual action of fast attack and counter-attack.
Rogulj et al. (2004)	90 matches Croatian League season 1998-1999.	MANOVA	Number of counter-attacks; of prolonged counter-attacks; short positional attacks; long positional attacks; uninterrupted attacks; single interrupt attacks; various interrupt attacks; In-game attack systems with one or two pivots; Attack organization Number of attack segments based on group cooperation; attack segments based on basic principles; Combination-based attack segments; attack segments based on group manoeuvres attack segments based on independent action; Attack direction attack segments to the right, left and center.
Gruić et al. (2006)	60 matches World Championship in Portugal 2003	Regressive Analysis	Frequency of successful shots (scored goals) or missed shots, which were made by first line players, wings and pivots of their play and counter-attack positions, as well as their assists and technical errors
Dumangane et al. (2009)	224 matches of the men's world championships 2001, 2003 and 2005	Linear Probability Model	Offensive actions and Goals.
Debanne et al. (2018)	68 matches of the French league, seasons 2012-2013, 2013-2014, 2014-2015, 2015-2016, 2016-2017.	Logistic regression analyses Multivariate logistic regression	The 7-meter throws; Situational Focus (when the 7-meter throw is executed during the final minute of the match); Reward Structure induced from the score difference between the teams and game location

The results of these types of investigations can provide valuable information for coaches that could optimize team and players' performance according to the specific variables considered.

2.5 Discussion

The objective of this review was to identify and summarize the most detailed literature on handball match analysis. We have identified the most frequently searched topics and characterized their methods. According to the previous systematic reviews on the analysis of collective sports matches (Agras et al., 2016; Sarmento et al., 2018; Sarmento et al., 2014; Silva, Sattler, Lacerda, & Joao, 2016), the common purpose of revised articles in handball is to describe the activity patterns of players and teams.

2.5.1 Descriptive Analysis

Players' and teams' actions during handball matches are registered using collecting systems that have vastly improved since the first simple manual collect systems videos (Prieto, 2015). However, although this process has evolved substantially in the amount and facility of data collection, studies are usually based on the frequency of actions and percentages of different performance indicators, which only provide information on what happened at the end of a game, without revealing the process of how this result happened during the match. (Prieto et al., 2015b).

The most commonly evaluated indicators present in these studies are the numbers of attacks made, offensive efficiency, shots taken, shots efficiency, goalkeepers' efficiency, average number of disqualifications, shots taken by backline players, wings and pivots, fast-break, quick attack and positional attack and 7-meter penalties (Bilge, 2012; Gutiérrez et al., 2011). For those analysis to be effective in the future, they must provide feedback to coaches and players before and after the match (Bilge, 2012; Gutiérrez et al., 2011).

The number of scored goals by the player is the main reason for the teams' success and depends on various factors: collective actions, individual actions, or weak individual technique of the defenders, surpassed by the strength or individual techniques of the offensive players (Gutiérrez et al., 2011).

Gutiérrez et al. (2011) also consider the goalkeeper to be one of the primary indicators of defensive success; their study includes a methodology that allowed to approach the study of the anticipation of the goalkeepers through an analysis of the movement used by them to defend the ball, allowing the temporal and spatial orientations of the goalkeeper to be connected with anticipation of movement and decision making,

before the shot is realized.

2.5.2 Comparative Analysis

As researchers' objectives, the studies compare the performances of the athletes and teams, according to the final result of the match, the actions of the coaches, the location of the match, and the defensive process.

2.5.2.1 Time-Outs (TTOs)

Among the various options available to handball coaches to control the course of the match, the two main features are player replacement and time-out calls; in the case of handball, there are three TTO requests per match, with a maximum of two per period permitted (Gomes et al., 2014). Thereby, coaches can use time-out as a tool to influence team performance, since they can use this moment to give tactical instructions or to perform structural modifications (e.g., game system, tactical disposition of the players) (Gutiérrez Aguilar et al., 2016).

Related to the above-mentioned studies, it is vital for the coach to know when to call a TTO and the amount of feedback to be provided to the athletes (Guzmán et al., 2012). The relationship with the analysis of the TTOs requested by the coaches comes through structural changes in the match, thus exposing an external result of the request; furthermore, the quantitative analysis of the coach's verbal behaviour would aid in determining if the information on the performance variables was efficiently supplied (Guzmán et al., 2012).

When the team calls for a TTO, the tendency is to make substitutions of players and changes of defence. The number of positive actions of the team increases after requesting a TTO; a change in the defensive system alone does not change the positive action difference in a relevant way after requesting a TTO, but the effect is positive when players are replaced (Gutiérrez Aguilar et al., 2016). Also, the decision of when to call a TTO during the match can make a difference to the final result of the match as well as short-term performances of both teams (Gomes et al., 2014).

Prieto et al. (2016) state that TTO is used mainly by teams that are losing or that have had a negative partial on the scoreboard and want to restructure the team (Gomes et al., 2014; Gutiérrez Aguilar et al., 2016). Consequently, the losing teams, in turn, have the habit of

requesting it more often than the winning teams do.

Regarding the period of play, significant positive effects were found in the medium term; for the teams that made a TTO request in the first 20 minutes of each half of the match, there was always an increase in the goals scored (Prieto et al., 2016). Gutiérrez Aguilar et al. (2016) recognized that most of the TTO were requested in the last ten minutes of each period.

Coaches must be aware of their TTO calls, when the prevailing mood following positive actions and corrective actions are considered relevant, as players always need more information, even after a successful action. A second prominent position would be provided by the increase of doubt and insecurity that generates negative actions in the coach; this may be due to the reduction of effectiveness in the information processes and decision making in negative situations (Guzmán et al., 2012).

2.5.2.2 Home Advantage

The domestic advantage effect is an intriguing phenomenon that has been the focus of much interest in sport research; data have enabled identifying those statistics related to the match that are affected by playing at home or away and how these variables can be attributed depending on the particular context of the match according to the capacity of both teams (Lago-Penas et al., 2013).

There is a significant direct association between the advantage of playing at home and the points obtained in a competition. In addition, there is a significant inverse association between the advantage of playing at home and the final classification of a team (Gutiérrez Aguilar et al., 2014). Several studies have emphasized the need to adjust the team's ability to quantify the advantage of playing at home. Lago-Penas et al. (2013) consider this domestic advantage to be at the behavioural level as a psychological factor for athletes; in contrast, Pic (2018) explains that the existence of the advantage of playing at home exists mainly in the critical moments of handball games to obtain decisive success actions in favour of the home team.

The importance of these factors is reflected in the changes in team and player activities, and in the responses to game situations; the results are that home teams outnumber their opponents in terms of more aggressive defensive behaviour, such as blocked shots, highly successful defensive actions and anticipations that can generate errors of the visiting teams (Gomez et al., 2014). As a result, playing matches at home

causes players to make fewer mistakes (Krawczyk, 2015), which can be explained by the increase in player motivation and which can lead to a greater level of involvement in the match and greater accuracy.

Oliveira et al. (2012) studied the home advantage phenomenon and examined the five-minute periods in which teams scored more goals. The results confirmed the existence of a home advantage (64%), which was higher in balanced matches (71%) and lower in unbalanced matches (55%) but did not show any specific five-minute period of when the home advantage appeared. The last five-minute periods of each half of the match were those in which most goals were scored, especially in the second half.

Additionally, Pic (2018) verified the existence of home advantage at critical moments (match status and game result), while Oliveira et al. (2012) concluded that home advantage in handball depends upon the quality of opponent, and it is stronger in balanced games. Moreover, the authors concluded that the differences between the final outcome and game location were only identified in 6-m shot effectiveness.

Gomez et al. (2014) argue that the effect of the advantage at home can be affected by the interpretation of the referees that in turn influence the result of the match. In fact, a referee's decisions can favour local teams in disciplinary decisions. In addition, a feature of the visiting teams is that their defensive actions are poorer, due to dysfunctional aggression, which means that defensive players fail in preventing the attackers from making contacts; the players then end up committing absences or violations.

Team coaches should be able to consciously change the style of the match and change the players when the team is making a greater number of mistakes so that the team's own errors can be eliminated and those committed by the opponent can be used (Krawczyk, 2015).

In general, the results of the reviewed studies showed that there is a home advantage effect for most measures of performance and discipline at the team level. These results indicate that strategies in handball are influenced by the location of the game and teams can change their style of play accordingly.

2.5.2.3 Winners and Losers

Typically, team performance indicators are provided from the comparison of winners and losers, and it is stated that no difference was found in the game style (positioned and fast breaks). It is essential to note the importance of the indicators

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

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

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

Data Envelopment Analysis is widely used by researchers for the purposes of measuring productivity and relative performance. In particular, it is a non-parametric technique that allows comparing input and output data without statistical order assumptions (Charnes, Cooper, & Rhodes, 1978) . Gutiérrez Aguilar and Ruiz (2013) evaluate the cross-efficiency to measure the performance of each team, obtaining the performance classification of the teams that can be compared with the final classification of the tournament and, therefore, are able to establish a comparison between the performance of the match and the competitive performance of each team according to their level. The results identified 9 efficient teams and 15 inefficient teams. The efficient teams achieved the efficiency both through different patterns of the game and very specialized patterns of the game (e.g., good performance in the number of goals scored from

6m). Concerning the inefficient teams, the DEA model identifies areas of potential improvement in each team (e.g., need to improve the efficacy of goals scored from the 9m and 6m).

2.5.2.4 Others Comparative Analysis

In addition to the comparative studies that focused their analysis based on specific variables of players or teams at various competitive levels, there were several studies that focused their analysis on other aspects, though less numerous.

The intensity and workload, intensity load, and volume load of a handball game are dynamically heterogeneous due to the very nature of this team sport, in which two opposing teams alternately assume the roles of attacker or defender. A complex system in sport, especially in team matches, consists of structural and functionally heterogeneous components that interact with different intensities and encompass different space-temporal scales (Prudente et al., 2017).

Analysts and coaches use performance indicators to evaluate the performance of an individual, a team or elements of a team, comparably using opponents, other athletes or groups of athletes or teams of peers, but often they are used in isolation as a measure of the performance of a team or individual (Prieto et al., 2015a). It allows them to choose the actions that best adapt to today's handball situations, directed directly to group tasks, such as two vs two situations within the match (Prudente et al., 2017).

The main results obtained by Meletakos and Bayios (2010); Meletakos et al. (2011) showed that the 6- and 9-metre throws had great relevance in the profile of the offensive teams. In particular, the efficiency of 6-metre throws remained constant in the three championships, while the effectiveness of 9-metre throws experienced a significant increase from 2005 to 2009. The authors argued that this was due to the increased quality of the pivots and their higher shooting efficiencies, which led the opposing teams to adopt special defensive tactics near the 6-metre line.

In identifying the offensive and defensive situations during a two-year cycle, Gryko et al. (2018) detects a change in the concept of playing in the positional attack in the 2015 championship in comparison to the 2013 championship; there were a significantly greater number of actions that led to a pitch in the region of 6 metres next to an opponent's goal area, as well as a higher level of actions and a more aggressive game by the defensive players; the European teams won more games than the teams of other

continents, demonstrating a superiority in the effectiveness of the technical-tactical actions of the match.

On the influence of the defensive fouls in the handball match, Fasold and Redlich (2018), when comparing the offensive actions where they happened, concludes that neither the strategy of stopping the offensive actions by corporal contact (fouls), nor avoiding fouls and focussing only on the interception of the ball, were a favourable solutions in the successful defence in the handball, being the most effective to implement a defence strategy with zones and situations to make fouls, clearly defined among the team, since the tactical possibility of making fouls is allowed in handball.

On the excess of more aggressive faults and fouls punishable, one a factor that shows no difference in the results of the match is the exclusion of two minutes; the study by Prieto et al. (2015a) show that in the sanctioned exclusions, opposing teams take advantage of numerical superiority and improve their score performance in the match. However, the punctuation increments were smaller than might be expected from numerical superiority. Psychological theories, such as asphyxia in situations of pressure, where good performance is expected and does not occur, may contribute to explain this finding.

Finally, it is known the goalkeepers play an essential role in defence and always try to minimize the success of opposing players. Handball has some areas of its field where goalkeepers have more advantages and more opportunities to defend the shots: the corners and the area behind the nine metres. Field players in attack in these areas attempt to overcome these disadvantages; this leads these players to find another way to be more effective (more technique and stronger shots). That said, the success of one or the other ultimately depends on the level of each performer (Hatzimanouil et al., 2017).

Thus, it can encourage a reflection in terms of planning for the coaches, helping to understand better how the result and the match time influence the efficiency of the actions, taking into account the tendencies in the game evolution (Prudente et al., 2017).

2.5.3 Predictive Analysis

The hierarchical model of performance structure in handball is meant to describe the situational action or efficiency of handball players' performance, which in turn defines the outcome of a match and, consequently, its overall sporting achievements in a competition (Gruić et al., 2006). The results of the analysis indicated the feasibility of

detecting the performance parameters in the offensive process of the teams. However, in interpreting the obtained results one must be careful; despite its relatively high statistical significance, the proportion and structure of the case samples and observed variables limit, to some extent, the virtue of the results obtained (Gruić et al., 2006; Rogulj et al., 2004).

Dumangane et al. (2009) examined whether the offensive and defensive performance of the teams influenced the probability of scoring in the match. A linear probability model was developed to estimate the probability of scoring as a function of the previous team performance. The main results showed that the scoring probability does not appear to have been influenced by the previous offensive performance of the attacking team, but indirectly by the past offensive actions of the opposing team.

Focusing only on the offensive aspect of the game, Rogulj et al. (2004) studied 19 elements of collective attack tactics, differentiating between winning and losing teams. It was found that the winning teams made continuous and short attacks against unorganized defences and short positional attacks (less than 25 seconds). It was discovered that losing teams performed long positional attacks, one pivot attack, low tactical complexity attacks, attacks based on individual player attempts, and attacks based on group cooperation and group manoeuvres of only a few team players.

Srhoj et al. (2001) analysed the influence of 18 indicators of the positional direction of the final conduct of the attack on the final result of the match. The results of the study showed that the players in the centre position were those who performed the final conduct of the attack more frequently. The best effectiveness of the shots was presented in situations and short distance shots. The lowest effectiveness of finalization was presented in long-distance shots and shots with small angles (wings); the variables related to the indicators of general engagement of the attack activity directed to the final conduct of the attack have no significant influence on the result. This means that the resulting success is not conditioned by the quantity but by the quality of the shots.

With another perspective of match analysis in a more psychological context, the purpose of Debanne (2018) study was to examine the connection between shooters' motivational orientations and their performance in a real-time environment at a crucial moment in the match and to evaluate the location effect successful seven-metre penalty throws in a handball match, evaluating performance in a real environment for understanding human psychological behaviour in a stressful context. As a consequence,

regarding the shooting situation of seven-metres, the authors suggest systematically perceive it critical to reduce the score difference independent of the moment of the match.

Although the literature emphasizes the importance and relevance of this type of research and despite the constant use of sophisticated analytical techniques/game analysis, there are still few available studies that have worked on developing and predictive models of sports performance in handball.

2.6 Conclusion

Research on performance analysis in sports, match analysis, has evolved over the years, mainly due to tremendous technological advances. In the case of handball match analysis, published studies examined the performance of players and teams with different complexity perspectives. The studies are based on the actions of the players and teams, are recorded to obtain a final set of data and thus describe what happened at the end of the match, without considering how it happened.

It can be observed that most articles focused on the study of offensive actions. In turn, many of the aforementioned studies focused their analysis on four main performance variables that seem to assume a greater importance: i) in the shots where the main action under study, in relation to which different positions of the players, distances and situations of the game; ii) the differences between winning teams and losing teams; iii) Time Outs and their importance to coaches and teams; and iv) the relation between matches as home team and visitor. Regarding the methods of analysis, articles from the statistics perspective were based on descriptive and comparative studies of the cumulative statistics at the end of the match. In contrast, studies using the dynamic approach have used a variety of advanced analysis techniques to evaluate the time evolution of performance during the match.

This systematic review can provide useful information on potential lines of work for performance analysts in the field of handball match analysis. The general guidelines for future work on handball match analysis include, but are not limited to, i) comparison of winning teams throughout sporting seasons, ii) understanding the effects of major indicators in different match periods, iii) understanding evolutionary tendencies of the match during several times, iv) conducting more studies focused on the defensive profile, v) analysing international club competitions, vi) analysing video matches and not using other reports provided by the tournament organization, vii) using standardized variables

for all researchers.

In this sense, there is a need to promote the development of systems for analysing the performance of athletes and teams that allow continuous and sequential mapping of actions occurring in the game. In this way, we will facilitate a more profitable relationship between science and practice, enhancing the collaboration between coaches and scientists.

Limitations of the reviewed studies are related to the default definitions of terms and conflicting expressions of activities and actions, which make it difficult to compare a similar group of studies. The use of studies with teams of different levels and different national championships also complicate the standardization of conditioned groups, thus hindering a replication of the studies and their future comparisons.

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Chapter III

A validation of a notational instrument

Chapter III

Validation of notational instrument

DEVELOPMENT AND VALIDATION OF A NOTATIONAL INSTRUMENT IN THE OFFENSIVE PROCESS IN HANDBALL

Chapter 3. Development and validation of a notational instrument in the offensive process in handball

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3.1 Abstract

This study aimed to develop and validate an instrument of observation of the offensive process within the handball context. Was used 3 EHF CL games as a basis to determine the macrocategories to be analysed and then a questionnaire was applied to qualified coaches in handball, about the variables in relation to the fundamental functions of the offensive game process. The analysed variables should contain more than 65% positive responses by the coaches to be representative. As a result of the investigation, handball coaches considered the following macrocategories, referring to the following indicators: 1) Offensive actions: Positional Attack, Fast Attack and Counter-attack; 2) Shooting indicators: 9 meters, between 9 and 6 meters, 6 meters and 7 meters; 3) Collective actions: Type - I, Type - II, Type - III and 4) Field zones. Based on the results obtained, it is concluded that the observation system covers all fundamental aspects of the game and as such can be used for the collection and process the information for a long-term analysis of the different variables of the offensive process in the handball game.

KEYWORDS: Observational methodology; Game analysis; Match analysis; Observation system.

3.2 Introduction

In sports, in a broad sense, situations, routines, strategies and tactics occur, whose knowledge and comprehension are essential to describe, interpret and analyse the collective behaviour (Mendo & Pollán, 1996), being the reason why coaches and investigators resort to the observation of the activity of players and teams to examine and study the game, with the goal of increasing the process of sports preparation (Garganta, 1998; Hughes & Bartlett, 2002; Lames & Hansen, 2001). With this, handball emerges as a dynamic and interactive activity, where two teams face each other, being subject to a great variability of actions that might affect the score of the game (Srhoj, Rogulj, & Katić, 2001).

The scored goal, being the main purpose of an attack by both teams, is the result of the cumulative individual activities done by the players in a certain game, something that emerges, mainly, in attacking situations (Gruić, Vuleta, & Milanović, 2006; Meletakos & Bayios, 2010). In this perspective, the scored goal, in handball rules, is the only element that is attributed a nominal numeric value, that defines the cumulative involvement of both teams (Rogulj, 2000, 2003;Ohnjec, 2008) structuring the final score of a game directly.

Statistics and traditional analyses techniques (e.g., IBM-SPSS Statistics) are an instrument to follow and explain what was observed in the "past" and determine what a team must do in the "future" (Starkings, 2008). With this, the game analysis might change, significantly, according to the discrete data about a specific player's activity or of each of the team's element (Carling, Reilly, & Williams, 2007) and according to of the definition of the efficiency criteria of the team and the players (Anguera, 1988; Mendo & Macías, 2002).

The results of this kind of analysis might reveal critical information about a team's strengths and weaknesses (Alford, 1998). In this case, the need for objective tools to evaluate the individual and team's performance will take an increase of the register and analysis of games and sports events (Cooper & Siedentop, 1975). So, observing players and teams during their performance is essential to the organisation, teaching and training of collective sports, as is the case of Football and Handball (Hughes & Bartlett, 2002; Hughes & Franks, 2004).

The majority of the researches in this area focuses, essentially, on the performance aspects that determine the sporting success and the final result of the action (O'Shaughnessy, 2006; Taborsky, 2000). This way, performance analysis in handball demands, in its conceptual approach, a paradigm change, where players conduct and actions in handball are determined by their tactical action (García, 1998), allowing to a better understanding of the performance in collective sports (Garganta, 1998; Konzag, 1991).

With this, the purpose of this article is to show the result of a construction and validation process of an observation instrument that allows a reliable registration of the players and teams behaviours and interactions through the analysis of the actions and sequential patterns in the offensive part of a game of high performance in handball.

3.3 Methods

Based on observational methodology, we followed methodological proceedings adopted by Prudente, Garganta, and Anguera (2004) that recommend the use of category system and the field zones format also corroborated by Anguera (2003), where he indicates to be important the junction of one or more category systems in one or more criteria or macro-categories.

In a way to operationalize the macro-categories of the observation instrument of this study, we determined the following goals: i) determine sequential patterns performed by teams in the offensive phase and relate them with the final score of the game; ii) consider the way of how the attack develops from specific game situations; iii) analyse the shooting action, before the 9 meters perimeter, between the 6 and 9 meters, and on 7 meters penalty; iv) analyse the method of the offensive game of positional attack, fast attack and fast-break.

On a first phase, the structure was dimensioned in the identification of the macro-categories, going to the discretion of the variables that we intended to study at this point, and we resorted, as in similar studies (Prudente et al., 2004; Sarmento, Anguera, Campaniço, & Leitão, 2010) to the observation of three games of the elimination phase of the handball champions league, EHF Champions League, of the 2015/2016 (n=1) and 2016/2017 (n=2) seasons. Lastly, we concluded the process with construction and posterior application of the questionnaire.

3.3.1 Construction of the Observation Instrument

The observation instruments built and validated by several authors (Falkowski & Enríquez, 1988; Garganta, 1997; Lago-Peñas, Lago-Ballesteros, Dellal, & Gómez, 2010; Leitão, 1998; Skarbalius, Pukėnas, & Vidūnaitė, 2013) were in the genesis of the creation of an analysis and observation instrument considered in this study, that emerges from a combination of offensive actions, game system indicators and their spatial evolution.

3.3.2 Macro-Categories and Study Indicators

We identified the macro-categories, and the indicators referred to the offensive behaviour demonstrated by game actions, the performance indicators translated by the player's efficiency in scoring situations and, finally, game indicators that are determined by game actions that fall into the pattern of collective game provision (Table 3.1).

Table 3.1. Macro-categories and Proposed Indicators

Offensive Actions	Positional Attack
	Fast Attacks
	Counter-attack
Identification of the action zones of the shot	9 meters
	9 – 6 Meters
	6 Meters
	7 Meters
Collective actions	Action Type – I
	Action Type – II
	Action Type – III
Field Zones	8 – Defensive Zones
	9 – Offensive Zones

3.3.3 Identification of the variables of the observation Instrument

The definition of each one of the variables is an important landmark to understand the meaning and attribute the level of importance that each one of them has for the identification of the handball game. Based on the orientation given by the research done in this study's area, we considered a number of variables that are part of the final document after the validation was done by a group of experts and technicians of the sport.

3.3.3.1 Offensive game action

In the offensive process, we considered three types of game actions:

1. **An action is considered when each player occupies his specific position and initiates interactions to move the defence, this phase begins when the opponent's defence is established in their position, against an organized offensive system,** Positional Attack **(Leitão, 1998). Identified as** Question 1 **in the questionnaire.**
2. **Might be considered as a second offensive wave, done by the most backward players in the defensive system, who progressed in the field through Fast passes, with speed, to the attack, with the purpose of creating a superiority situation or defensive disorganisation of the opponents' team,** Fast Attack **(Falkowski & Enríquez, 1988; Garganta, 1997). Identified as** Question 2 **in the questionnaire.**
3. **This offensive method begins in the defensive field, and the opponent's team comes up high on the field and unbalanced on the defensively, trying to get as Fastly as possible to the opponents' goal,** Counter-attack **(Falkowski & Enríquez, 1988). Identified as** Question 3 **in the questionnaire**

3.3.3.2 Identification of shooting action zones

This study pretends to make a more precise evaluation of the zone of the shooting action materialised by the handball players. We opted by subdividing into four zones of shooting (Bilge, 2012; Ferrari, Vaz, & Valente-dos-Santos, 2014; Skarbalius et al., 2013), this way:

1. **When a player that shoots, has his last step with the foot placed before the marked line, shots in the 9 meters zone. Identified as** Question 4 **in the questionnaire**
2. **The player, with his jump, invades the aerial space of the area, where he had to shoot before his landing (which succeeded inside the aerial space of the opponents' area), shots from the 6 meters zone. Identified as** Question 5 **in the questionnaire.**
3. **It was done when a 7 meters penalty was taken, shots from the 7 meters zone. Identified as** Question 6 **in the questionnaire.**
4. **The player that shot had his support foot touching the ground, between the dashed line (9 meters) and the 6 meters and he would not invade the aerial space of the area during the shooting, shots from 9 and 6 meters zones. Identified as** Question 7 **in the questionnaire.**

3.3.3.3 Collective actions

With the new rule changes about the passive play in handball, the interest in adopting designations for this type of actions that are congruent with the nomenclature of other collective sports. With that, we considered actions that corresponded to the dynamic

or static actions that assured a beginning, a progression and an end, being grouped by the following way (Gama et al., 2014; Vaz, Gama, Valente dos Santos, Figueiredo, & Dias, 2014; Vázquez, 1998):

1. **It was characterised completed collective actions (beginning, progression and end) occurring from dynamic or static play, without the possibility of shooting in the short term (Gama et al., 2014; Vaz et al., 2014; Vázquez, 1998). Identified as** Question 8 **in the questionnaire.**
2. **Represented incomplete collective actions (beginning and progression) that occur from dynamic or static play, without the possibility of shooting (Gama et al., 2014; Vaz et al., 2014; Vázquez, 1998). Identified as** Question 9 **in the questionnaire.**
3. **They were identified as collective actions, beginning in a free kick, with the possibility of a short-term shot (e.g. 7 meters penalty and/or shooting right after taking some 9 meters fault) (Gama et al., 2014; Vaz et al., 2014; Vázquez, 1998). Identified as** Question 10 **in the questionnaire.**

3.3.3.4 Field zones

When we talk about spatial location, it was proposed an adaptation of the field zones used by (Prudente, 2006), adding more defensive and offensive of the zones A and D 6, 7 and 8, where the author considered just one spatial location of the field zones, setting up the field in 17 zones and 5 corridors, that corresponds to 8 zones of the defensive part and 9 zones of the offensive part, considering the numbering of designated zones according to the direction of the attack (Figure 3.1).

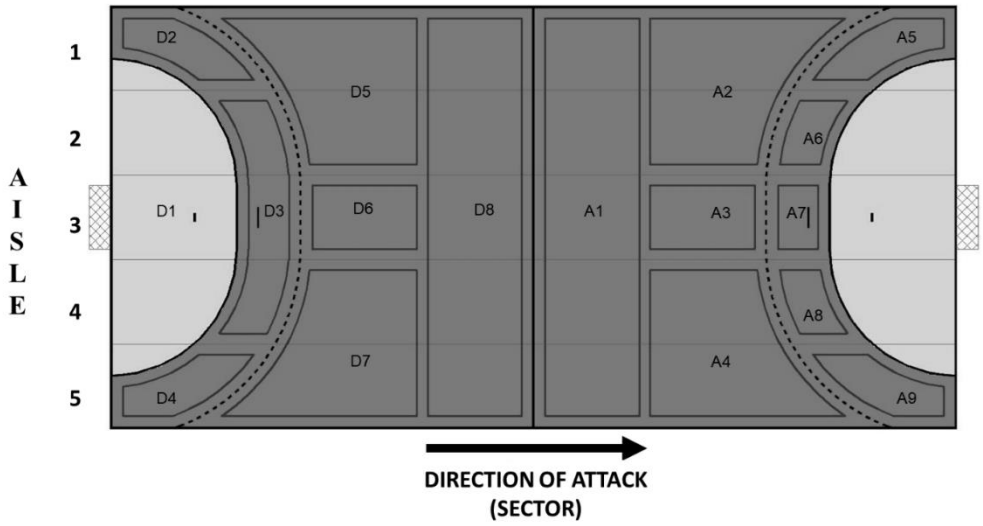

Figure 3.1. Field zones (adapted from Prudente, 2006); D – References the Defensive Zones; A – References the Offensive Zones.

3.3.4 Questionnaire Construction

To prepare and validate the observation instrument, beyond the literary review, we used the following procedures: i) do an exploratory observation period, on which were observed the footage of several handball games; ii) define the criteria that was proposed and make a list of observed behaviours for each one of them, in a way to enable the registration of game actions; iii) a group of experts were analysed to the indicators of game performance to be included in the study (coaches and teachers); iv) on this last step, it was elaborated, applied and analysed an agreement with the literature and the observation described.

The dimensions considered relevant according to the theoretical framework and the consulted studies were that each one of them was used for a list of elaborated categories, according to several authors (Gutierrez, Montoya, Fernandez, & Saavedra, 2016; Prieto, Gomez, Volossovitch, & Sampaio, 2016; Prudente et al., 2004; Skarbalius et al., 2013).

To evaluate the answers of the interviewed people, nominal scales were used, that consisted of a set of answer categories qualitatively different and mutually exclusive. On the other side, on the last question of the questionnaire, we used an ordinal scale, where a numerical ordering of the analysed categories was operationalized, that is, from the alternative answers, establishing a relation of order between them, in a scale from 1 to 5, where 1 corresponded to "not adequate" and 5 to "rather adequate" (Magalhães & Hill, 2005).

3.3.5 Validation of the Observation System

This procedure had a pilot phase, where the purpose was to ascertain the possible perceptibility and accuracy of the analysis. It was intended to verify the degree of coverage of the observed instrument and underlying constructions around it, determined, hereby, if the proposed categories effectively described the performance and the interactions occurred during a handball game (Hassan, Schrapf, Ramadan, & Tilp, 2017; Schrapf, Alsaied, & Tilp, 2017; Sousa, Prudente, Sequeira, López-López, & Hernández-Mendo, 2015).

For this purpose, three games were observed, and 20 days after the first data collection, the three games were repeated by the observer. For the reliability index inter-observer, it was selected a coach (Master Coach/Pro Licence), where he had preparation about how to make collections and after the training period, he repeated the process.

To Sampaio and Janeira (2001), the degree of reliability of the methods and means of game analysis determines the quality of the performed measurements, as well as the quality of subsequent decisions. Therefore, in this article, the reliability of the intra-observer and inter-observer is important, because it offers the guaranty of internal consistency. Estimating this reliability, allows us to see if an observer is consistent in his In the study of answers that resulted from the process of validation of the observation instrument, it was applied basic criteria, where the agreement degree between the different performance indicators took into account the attributed percentages, considering as cut value above 65%, an agreed numbered that corresponds to 40 of the 61 analysed specialists (Prudente et al., 2004; Santos, Sarmento, Alves, & Campaniço, 2014; Sarmento et al., 2010).

Reliability in studies of this level has a significant importance in the results, that is, the reliability of the data collection. In this study, we opted to analyse data quality through intra-observer and inter-observer agreement, which was verified through the Kappa Cohen reliability index (Cohen, 1960). Examining the values obtained for each criterion, we conclude that the results showed a high stability between intra-observer observations 0.91 and inter-observer 0.89.

With the adjustments made based on the processes described above, the final version of the observation instrument for the handball game was conceived, consisting in macro-categories, observational categories and attributing individual codes for each one of the observed categories (Table 3.2).

Table 3.2. Mixed system of field format with category systems for observation of the offensive sequences in handball.

Macro-Categories	**Categories Observational**	**Codes**
Offensive actions	- Positional attack	AP
	- Fast attack	AR
	- Counter-attack	CA
Shooting action zone	- 9 Meters	9M
	- 9 – 6 Meters	9-6M
	- 6 Meters	6M
	- 7 Meters	7M
Collective actions	- Action Type – I	ATI
	- Action Type – II	ATII
	- Action Type – III	ATIII
Field zones	- Defence Zone	D1, D2, D3, D4, D5, D6, D7, D8
	- Attack Zone	A1, A2, A3, A4, A5, A6, A7, A8, A9

Note. D – References to the Defensive Zones A – References to the offensive zones.

By using the registration software *VideObserver,* we inserted the alphanumerical codes, facilitating its coding and data analysis, considering this procedure more efficient to the observer.

3.4 Application of the Questionnaires and Analysis of Results

After the final construction of the questionnaire, it was applied an inquiry via *Google Forms,* sent to the Portuguese Handball Federation and Handball Associations in Portugal. Who, in their turn, sent it to the coaches that possess coaching certificate, in the context of National Plan of Training Coaches, in which 61 coaches participated.

The sample consisted of 61 people. In this case, 18 of them had a degree in Sports Sciences and Physical Education, 10 with the Master's Coach/Pro Licence degree, 29 with the grade 3 coaching degree, three coaches with the grade 2 coaching degree and 19 coaches with grade 1 coaching degree. The average age and standard deviation of the participants were 34,95 ±9,43 years, the years of experience as coaches presented an average age and standard deviation of 11,07 ±9,23 and about the gender of the sample, 13 were female, and 48 were male (Table 3.7 in attachment).

We collected the questionnaires and proceeded to their analysis, based on the division of the proposed macro-categories that we will present.

3.4.1 Offensive actions

With the purpose of verifying the coaches' opinion about the rating of the offensive actions, according to the definition presented in literature and spilled in methodology in which the positional attack was considered by Leitão (1998) and Fast attack, based in Falkowski and Enríquez (1988); Garganta (1997), as for the Counter-attack, where the assumptions of Falkowski and Enríquez (1988) were followed. The answers allowed us to evaluate the agreement between coaches (Table 3.3).

Table 3.3. Grade of agreement attributed to the different indicators about the Offensive Action.

Offensive Action	Positional attack (organized)	Fast attack	Fast-Break
Question 1	61 (100%) *	0	0
Question 2	1 (1,64%)	46 (75,41%) *	14 (22,95%)
Question 3	0	3 (4,92%)	58 (95,08%) *

Note. ** Indicators above 75%*

The results show that for the positional attack, of Question 1, coaches agree with the proposed definition, presenting a total value of 100%. The same happens for the Counter-attack, Question 2, where the answers stand at 95,08%. For the Fast attack, we found disagreeing answers (22,95%), but the volume of agreeing answers stood at 75,41%, which is within the defined parameters for the cut value (65%).

3.4.2 Shooting action zones

The inquiries done to the coaches about the shooting action zones meant the inclusion of a new aspect, regarding the distances allocated, where it was included the shot between the dashed line of the 9 meters and the 6 meters (Skarbalius et al., 2013). However, there is not any literature that differentiates this kind of shot from the ones taken from behind the 9 meters dashed line and the ones taken before the 6 meters,

becoming more complex to make a differentiation when we analyse the distance in which they were taken (Table 3.4).

Table 3.4. Degree of agreement attributed to the different indicators about the Shots.

Shots	9 meters	9 - 6 meters	6 meters	7 meters
Question 4	60 (98,36%) *	*1(1,64%)*	0	0
Question5	0	1 (1,64%)	60 (98,36%) *	0
Question6	0	0	0	61 (100%) *
Question7	2 (3,28%)	53 (86,88%) *	4 (6,56%)	2 (3,28%)

Note. * Indicators above 75%

The shooting zones from the back line to the 9 meters (Question 4) and the 7 meters zone (Question 6) obtained the same values (100%), considering that in the first case the situation that the player shooting had the last step behind the dashed line of the 9 meters, and there was no doubt about the 7 meters line, since it is considered a penalty in the 7 meters line.

About the 6 meters shots (Question 5), where the player, through his impulsion, invaded the aerial space of the area, where the shooting action had to occur before his fall (which succeeds inside the aerial space of the opponents' area), the values stand at 98,36% of agreement between coaches.

The player that made the shot with his last step touching the ground, between the dashed line (9 meters) and the 6 meters line (Question 7), without invading the aerial space of the area while shooting, named as action of the shooting zone between 9 and 6 meters, got an agreement of 86,88% from the coaches. However, there are other opinions that take these actions to the 6 meters zones (6,56%), 9 meters and 7 meters with identical values (3,28%).

3.4.3 Collective actions

The collective actions of the game correspond to the dynamic or static actions that assure a beginning, a progression and an end (Falkowski & Enríquez, 1988; Gama et al., 2014; Vaz et al., 2014; Vázquez, 1998). This way, in coaches' opinion, there was an agreement consensus above the 90% on the three questions made (Table 3.5).

Table 3.5. Degree of agreement attributed by coaches to the different indicators and collective actions.

Collective actions	Yes	No
Question 8	57 (93,44%) *	4 (6,56%)
Question 9	59 (96,72%) *	2 (3,28%)
Question 10	56 (91,8%) *	5 (8,20%)

Note. ** Indicators above 75%*

On the collective actions Type – I (Question 8), in the complete collective actions, we verified an agreement of 93,44% by the coaches.

The offensive actions that represented an incomplete action, without the possibility of shooting (Question 9), obtained 96,72% on the answers given by the coaches, considering them as collective actions Type – II.

The identification of collective actions coming from free kicks, with the possibility of a short-term shooting as the 7 meters penalties and/or shooting right after the 9 meters free kick (Question 10), where they were considered collective actions Type – III, obtained 91,8%.

3.4.5 Field zones

The proposal of adding more divisions in the offensive and defensive zones in the adaptation of adding a field zones used by Prudente (2006), got an agreement by coaches to this methodology as very adequate and 15 coaches considered it adequate to collect handball data (Table 3.6). We verified that the sum of the scale 4 and the scale 5 we obtain a value of 74% above the cut value considered to validate the questionnaire.

Table 3.6. Degree attributed by coaches from the coaches about the Field zones indicators.

Field zones	1- Not adequate	2- Little adequate	3- Adequate	4- Very adequate	5- Rather adequate
Concordances	1	4	11	30	15
Percentage	1,63 %	6,55 %	18,03 %	49,18 %	24,60 %

3.5 Conclusion

As it was indicated in the introduction, the majority of researches settles in performance aspects that determine the sports success and the result of the action. (O'Shaughnessy, 2006; Taborsky, 2000). As we tried to alter this kind of approach in handball performance analysis, where the conducts and actions of the players are determined, essentially, by tactical action (García, 1998), allowing to understand better the performance in collective sports (Garganta, 1998; Grehaigne, 1992; Konzag, 1991), we tried, in the first place, to build a validation instrument, through the identification of the collective actions, getting to the typology of the collective actions after and ending in the shooting process involving all the procedure in the definition of a field zones to help the best structure of an handball game.

The analysis of the results allows coaches to observe a possible relation between structural behaviours of the game, something that might contribute, regarding practical applications, to the optimisation of the sports performance individually and collectively.

Other than that, the validation provided by the sports experts, after presenting the definitions of several authors, allowed us to build an analysis instrument that identifies the indicators that characterize the typology of offensive games of each team as indicators of offensive actions (positional attack, Fast attack, counter-attack), shooting zone indicators (9 meters,9 - 6 meters, 6 meters and 7 meters), indicative of collective actions (collective action type – i, collective action type – ii, collective action type iii) and the field zones.

Summarizing, following Ferrari et al. (2014); Prudente et al. (2004); Vaz et al. (2014), the instrument presented here will serve, eventually, to better characterise and understand the dynamics of a handball game, of high-level teams, especially in the offensive process. It is about a mixed system of analysis that allows the coach bigger flexibility analysing his teams' and opposing teams' performances, also giving a micro approach (of a specific action) and macro (of a group of actions), that can help to understand better the performance of this collective sport.

3.6 Attachment

Table 3.7. Characterization of the study sample

Code	Age	CDEF Teacher	Coach Degree	Experience (years)	Nat.
1	31		Degree - 3	6	
2	31		Degree- 3	5	
3	33		Degree- 1	4	
4	30		Degree- 3	10	
5	31	X	Degree- 3	5	
6	34		Master Coach / ProLicense	13	
7	37	X	Master Coach / ProLicense	20	
8	63	X	Master Coach / ProLicense	40	X
9	30		Degree- 3	5	
10	33		Degree- 3	10	
11	34		Master Coach / ProLicense	13	X
12	22		Degree- 1	2	
13	30	X	Degree- 3	11	
14	34	X	Degree- 3	16	
15	30		Degree- 3	12	
16	32	X	Degree- 3	16	
17	42	X	Degree- 1	3	
18	20		Degree- 1	2	
19	36	X	Degree- 1	3	
20	25		Degree- 1	2	
21	60		Master Coach / ProLicense	36	
22	53		Degree- 2	35	
23	43		Degree- 1	3	X
24	35		Degree- 1	1	
25	28		Degree- 3	10	
26	28		Degree- 2	12	X
27	19		Degree- 1	1	
28	42		Degree- 3	24	
29	36		Degree- 3	19	
30	28		Degree- 3	10	X
31	44		Degree- 3	4	X
32	33	X	Degree- 3	12	
33	33		Degree- 3	7	
34	27		Degree- 1	4	
35	45	X	Master Coach / ProLicense	15	X
36	33		Grau - 3	15	
37	44		Master Coach / ProLicense	10	
38	24		Degree- 1	6	
39	43		Degree- 1	16	
40	22	X	Degree- 1	3	
41	48		Degree- 3	30	
42	56		Degree- 3	30	
43	30	X	Degree- 3	8	

44	28		Degree- 3	6	
45	49	X	Master Coach / ProLicense	30	
46	26	X	Degree- 3	8	
47	30		Degree- 1	8	
48	49	X	Master Coach / ProLicense	26	
49	37		Degree- 2	17	
50	31		Master Coach / ProLicense	14	X
51	26		Degree- 1	6	
52	23		Degree- 1	3	
53	41	X	Degree- 3	10	
54	37		Degree- 3	13	
55	25		Degree- 1	1	
56	27	X	Degree- 3	9	
57	39		Degree- 1	3	
58	44		Degree- 3	10	
59	33		Degree- 3	17	
60	34	X	Degree- 1	9	X
61	41		Degree- 3	15	

Subtitle: Cod. – Code adopted for each coach; Nat. He was part of the National Selection of his Country.

3.7 References

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Chapter IV

Original Study 1

Chapter IV

Study 1

Comparative analysis of the offensive effectiveness in winner and losing handball teams

Chapter 4. Comparative analysis of the offensive effectiveness in winner and losing handball teams

Reference: *Ferrari, W., Dias, G., Sousa, T., Sarmento, H., & Vaz, V. Comparative Analysis of the Offensive Effectiveness in Winner and Losing Handball Teams. Frontiers in Psychology, 2020. 11(2566). doi:10.3389/fpsyg.2020.547110*

4.1 Abstract

The purpose of this study was to determine differences related to the offensive process between winning and losing teams among teams participating in the European Handball Federation Champions League (EHFCL) in 55 matches across 5 seasons. The key indicators used in this study are the offensive actions, team possession type and the zones of the field, goals, and shooting effectiveness. A total of 34 indicators were analysed and compared using Mann-Whitney U tests. Sixteen key indicators are identified to confirm differences both from the aspect of the collective game in terms of assists (9.10 ± 2.75 *vs* 7.29 ± 2.65), goals of positional attack (21.38 ± 4.60 *vs* 18.20 ± 3.62) and from the aspect of individual goals from 6 meters (16.67 ± 3.98 *vs* 13.64 ± 3.70), and the effectiveness of shots (68.19 ±6.83 *vs* 59.41 ±6.33). Winning teams performed better regarding the variables that defined the effectiveness of offensive shots, especially successful positioned attacks and fast attacks. They also had a greater number of assists. The profiles of the most successful teams can help coaches and practitioners to achieve better performances adjusting the training process according the performance indicators that seem to lead more often to success.

KEYWORDS: Match analysis; Performance analysis; Observational methodology, Team sports.

4.2 Introduction

Handball is a complex sport in which players' performance can be analysed and presented in various manners (Skarbalius, Pukėnas, & Vidūnaitė, 2013). Additionally, is considered a transition game, as players often alternate between defensive and offensive play and the actions of the match are characterised by alternations between running and sprinting (Curiţianu, Balint, & Neamţu, 2015). Technical skills, anthropometric characteristics, and high levels of muscle strength and speed are the most important factors in gaining an advantage in elite handball competitions (Gorostiaga, Granados, Ibanez, & Izquierdo, 2005; Rannou, Prioux, Zouhal, Gratas-Delamarche, & Delamarche, 2001). However, success in collective sports requires that a team integrate many factors beyond physical factors (Smith, 2003).

Among these other success factors is match analysis (Hughes & Bartlett, 2002). Over the years, match analysis has evolved very significantly in several sports, such as football (Sarmento, Clemente, et al., 2018; Sarmento, Marcelino, et al., 2014), futsal (Agras, Ferragut, & Abraldes, 2016) or basketball (Courel-Ibáñez, McRobert, Toro, & Vélez, 2017). Nerveless, the investigation in handball match analysis is not well established in the researcher's scientific agenda (Ferrari, Sarmento, & Vaz, 2019).

More specifically, past research in this scientific area reveal the interest of the scientific community in detecting the differences between winners and losers' teams. Comparisons between offensive and defensive actions, goals or points, interactions between players, and assists are the most commonly used factors assessed by researchers in basketball (Blake, 2015; Madarame, 2017, 2018), football (Lago-Peñas, 2007; Rumpf, Silva, Hertzog, Farooq, & Nassis, 2017; Sarmento, Figueiredo, et al., 2018; Szwarc, 2007), female handball (Costa, 2018; Ohnjec, Vuleta, Milanović, & Gruić, 2008), and other collective sports (García-Marín & Argudo Iturriaga, 2017; Vaz, Mouchet, Carreras, & Morente, 2011).

Specifically, in male handball, Skarbalius et al. (2013), concluded that goals, effectiveness of positional attacks, and shooting efficiency in the offensive process were important performance indicators that distinguished winner and losers teams. On the other hand, Vuleta, Sporiš, and Milanović (2015), concluded that there are six offensive indicators that differentiated winners from losers: goals at 6 meters, total goals, total shots, shots at 9 meters, counter-attacks and assists. Additionally, Ferrari, Vaz, and

Valente-dos-Santos (2014) also concluded that positional attack, penalties of 7m, and 9-meter shots and their effectiveness were associated with winner teams. Also, Meletakos, Vagenas, and Bayios (2011), showed that the 6- and 9-meter throws strongly impacted the offensive profile of the teams. In particular, 6-meter efficacy remained constant in all the competition analyzed in their study, while 9-meter effectiveness increased significantly over the years.

Contrary to what happens in other sports, as in football (Sarmento, Anguera, et al., 2014; Sarmento, Clemente, et al., 2018), futsal (Agras et al., 2016) or basketball (Courel-Ibáñez et al., 2017), the available literature on match analysis in handball is still scarce and focused mainly in four variables of performance: total number of shots and their effectiveness, match outcome, Time Outs, and the analysis centred in home advantage (Ferrari et al., 2019). In this sense, and according to (Meletakos et al., 2011; Prieto, Gómez, & Sampaio, 2015; Román, 2015), the existing handball performance analysis database is insufficient to allow coaches and match analysts to establish performance optimization criteria, and additional investigation is needed in order to better understand the specific influence of different performance indicators in the performance of the teams.

In this sense, the aim of the present study was to determine the differences between winning and losing teams participating in the EHFCL of men's handball in terms of their offensive processes (offensive type of possession, shoots, goals scored, interactions, assistances, turnovers and punishments) using notational analysis from five sporting seasons.

4.3 Material and Methods

4.3.1 Sample

We used data from the teams that participated in the EHFCL in the competitive moments of the quarterfinals and Final Four (n = 55) over five seasons (2012/2013 to 2016/2017). Only matches in which there was a winner were included. The teams that compete in this competition are considered the best club teams in the world. The selection to participate in this competition stems from the fact that they have won the respective national championships, representing the EHFCL as the main competition at European level of clubs, being also considered the most difficult competition at the level of clubs

worldwide. Naturally, these teams are made up of a large majority of those who are considered the elite athletes worldwide.

4.3.2 Measures

The observational instrument tool used to collect data is developed and validated by Ferrari, Vaz, Sousa, Couceiro, and Dias (2018b) and included a combination of offensive actions (organized attacks, fast attacks, counter-attacks, total shots, and total goals), team possession types (Table 1) and field of action (i.e., field zones) (Figure 1). Data collection and analyses were conducted according to the Declaration of Helsinki.

Table 4. 1. Description of variables and definitions of categories used in the team match performance analysis

Variables and categories
Team Possession Type
Positional attack - An action is considered when each player occupies their specific position and initiates interactions to move the defense, this phase begins when the opponent's defense is established in their position, against an organized offensive system.
Fast attack - is considered as a second offensive chance, made by later players in the defensive system, who progressed in the field with speed, through quick passes to the attack, in order to create a situation of superiority or defensive disorganization of the attack to opponents' team
Counter-attack - This offensive method starts in the defensive field, trying to get as fast as possible to the opponents' goal with as few passes as possible.
Type of offensive actions
Collective actions Type – I - complete collective actions (e.g., start, progression and completion) are those that result from dynamic or static play, implying a start, a progression development in the field of play for more offensive areas and a finalization of the offensive sequence (with or without efficiency).
Collective actions Type – II - incomplete sequence, that result from loss of ball due to technical or tactical error
Collective actions Type – III - actions that start by a stopped ball situation (e.g., 7 meters penalty shot, direct or indirect free kick, foul, etc.) that imply a short finalization and imply a rapid finalization of the offensive process (less than 3 passes between the players)
Finishing zones
Before 9 meters - any action that was completed before the dashed line of the 9 meters represented in Figure 1 (A1, A2, A3 and A4)
Between 9 - 6 meters - any offensive action that was completed after the 9-meter dashed line represented in Figure 1 (A5, A6, A7, A8 and A9)
Defense zone - any action of the offensive process that has been completed in the zone of defense represented in the figure as all zones containing "D"
Shooting zones
9 meters - The player making the shot has his last support foot placed before the dashed line
9 - 6 meters - the player who hit the ball had his support foot touching the ground, between the dashed line (9 meters) and the 6 meters
6 meters - the player, with his jump, invades the airspace of the area, where he had to finish before landing
7 meters - was carried out while 7 meters penalty shot was awarded
Defense - when the shot was taken from the field of defense of the team.

Effectiveness

With efficiency - shot with a goal scored

Without efficiency - recovery of ball possession by the opponent, ball out, violation of the rules of the game, shot defended by the goalkeeper, shot out, shot into the opponent.

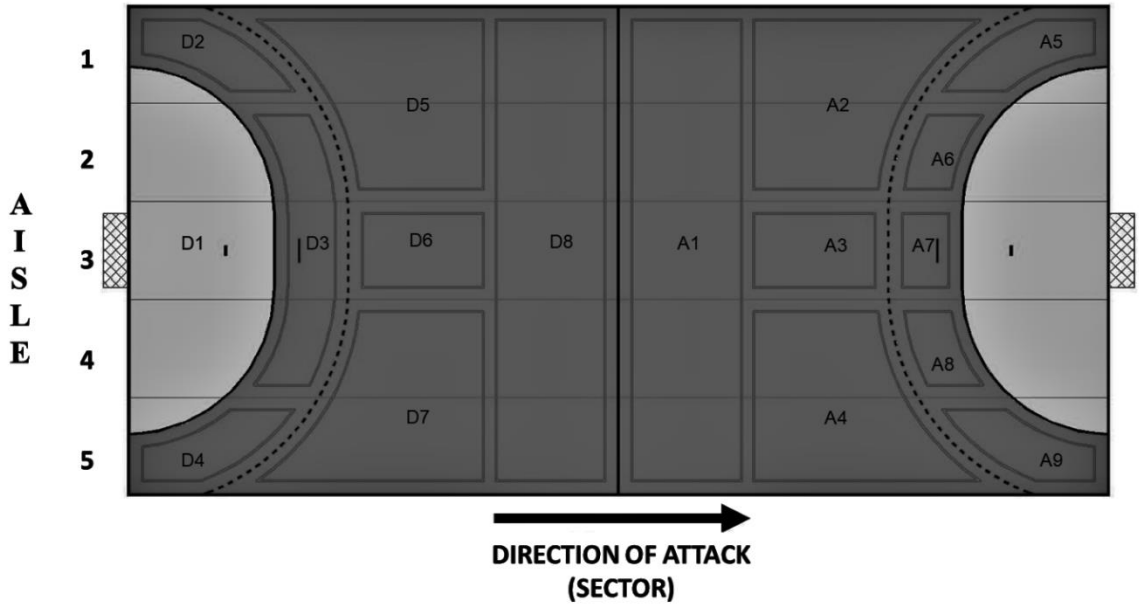

Figure 4. 1 Field zones divided into 17 zones and five aisles with the numbering of zones designated according to the direction of the attack.
Note. D – Defence; A – Attack

In addition to the means of observation mentioned above, effectiveness will be analysed in two ways: i) total efficacy, which is the ratio of total actions to their respective variables, and; ii) finishing efficiency, which is the ratio of the total number of goals scored relative to the total number of shots taken.

Data was collected for winning and the losing teams of matches simultaneously using Video Observer® software. Then, the data were entered into Microsoft Excel 2013 for further analysis. Each sequence has been analyzed in sequential way.

To ensure the reliability of the observations, intra- and inter-observer agreement were used for all the criteria, as stipulated by the Cohen's Kappa index (Cohen, 1960; Saavedra, Þorgeirsson, Chang, Kristjánsdóttir, & García-Hermoso, 2018), which was

greater than 0.91. For that, two experienced handball analysts in match analysis procedures used the specific observational instrument tool to analyse the selected offensive sequences. After a training period, each analyst had analyzed around 10% of the offensive sequences randomly selected, in order to analyse the interobserver reliability. Intraobserver reliability was completed using the offensive sequences of the same offensive sequences, but the lead author of this study repeated these on two occasions (after a 4-week period).

4.3.3 Statistical Analysis

The characterisation of the sample was produced through descriptive statistics using the parameters of average central tendency and dispersion (standard deviation and amplitude) to extract information regarding the general dynamics of handball matches (Bajgorić, Rogulj, Čavala, & Burger, 2017).

Non-parametric statistical analyses were performed using Mann-Whitney U tests, which identified a subset of variables related to the game that distinguishes the teams that have won from those that lost in each of the five EHFCL seasons. Cohen's d effect size was calculated and considered small ($d<0.2$), moderate ($0.2<d<0.6$), big ($0.6<d<1.2$), very big ($1.2<d<2.0$), or nearly perfect ($2.0<d<4.0$) (Cohen, 1988). The level of statistical significance was set at 0.05, and all analyses were performed in IBM SPSS Statistics (24.0).

4.4 Results

The results were distributed according four aspects of the offensive process: (1) the teams' offensive actions, (2) the goals scored by the teams, (3) goals scored in different finishing zones, and (4) the effectiveness of actions when a goal was scored.

Regarding offensive actions presented in Table 2, we concluded that winner teams scored more goals through positional attacks, and trough Action Type I, scored more goals (in total and from 6 meters line), and performed more assistances.

Table 4. 2. Results of the Mann-Whitney U test for offensive actions

	Winners (n = 55)	**Losers (n = 55)**	**Different from the winning team**	**Z**	***p***	**d**
	Mean ± SD (Min-Max)					
Actions	53.44 ± 6.01 (45-76)	53.40 ± 5.99 (45-76)	0.04	-0.51	0.95	0.00
Positional Attack	40.52 ± 5.37 (30-45)	40.47 ± 5.02 (32-55)	0.05	-0.75	0.94	0.01
G. Positional attack	21.38 ± 4.60 (12-31)	18.20 ± 3.62 (12-30)	**3.18**	**-3.86**	**0.00**	**0.76**
Counter-attack	5.52 ± 2.77 (1-16)	4.81 ± 2.41 (1-11)	0.71	-1.29	0.20	0.27
G. Counter-attack	4.24 ± 2.38 (1-13)	3.45 ± 1.68 (0-8)	0.79	-1.64	0.10	0.38
Fast Attack	7.38 ± 4.03 (1.17)	8.10 ± 4.33 (0-18)	-0.72	-0.99	0.32	-0.17
G. Fast attack	4.35 ± 2.39 (0-11)	4.27 ± 2.66 (0-11)	0.08	-0.47	0.64	0.03
Type Action – I	35.38 ± 5.69 (24-56)	34.72 ± 6.41 (22-55)	0.66	-0.85	0.39	0.11
G. Type Action – I	24.53 ± 4.38 (15-35)	21.09 ± 4.20 (13-34)	**3.44**	**-4.10**	**0.00**	**0.80**
Type Action – II	9.80 ± 3.42 (4-20)	10.05 ± 3.30 (4-20)	0.12	-0.47	0.64	-0.07
Type Action – III	8.16 ± 3.26 (2-16)	8.61 ± 2.80 (2-17)	-0.25	-0.90	0.37	-0.15
G. Type Action – III	5.44 ± 2.70 (1-12)	4.84 ± 2.58 (1-12)	0.60	-1.15	0.25	0.23
Shoots	45.47 ± 5.78 (33-66)	45.16 ± 6.62 (33-70)	0.31	-0.07	0.94	0.05
Total Goals	29.96 ± 4.40 (22-43)	25.93 ± 4.24 (15-39)	**4.03**	**-4.80**	**0.00**	**0.93**
Interactions	654.73 ± 84.72 (461-845)	661.09 ± 84.36 (458-818)	-7	-0.31	0.76	-0.08
Assistance	9.10 ± 2.75 (3-16)	7.29 ± 2.65 (2-14)	**1.81**	**-3.33**	**0.00**	**0.67**
Turnovers	9.80 ± 3.42 (4-20)	10.05 ± 3.30 (4-20)	-0.25	-0.47	0.64	-0.07
Punishments	3.76 ± 1.62 (0-8)	3.96 ± 1.80 (0-9)	-0.20	-0.62	0.53	-0.12
G. 9 meters	5 ± 2.76 (1-12)	4.96 ± 2.72 (1-12)	0.04	-0.60	0.95	0.01
G. 9 - 6 meters	5.05 ± 2.31 (0-11)	4.49 ± 2.04 (1-10)	0.56	-1.36	0.17	0.26
G. 6 meters	16.67 ± 3.98 (10-29)	13.64 ± 3.70 (7-25)	**3.03**	**-3.46**	**0.00**	**0.79**
G. 7 meters	2.98 ± 1.80 (0-7)	3.07 ± 1.76 (0-8)	-0.09	-0.39	0.69	-0.05
G. Defence Zone	0.24 ± 0.51 (0-2)	0.20 ± 0.45 (0-2)	0.04	-0.28	0.78	0.08

Note. G. – Goals

Table 3 present the results concerning the comparison relationships between goals in the different offensive areas of the field zone. It is important to highlight that winner teams scored more goals from the central (A7) and right (A8 and A9) zones of the offensive midfielder when compared with the loser teams. For both winner and loser teams, the central zones of the offensive midfield (A6, A7 and A8) were the zones from where the most goals were scored.

Table 4. 3. Results of the Mann-Whitney U test for goals scored in the final zones of action.

	Winners (n = 55)	**Losers (n = 55)**	**Different from the winning team**	**Z**	***p***	**d**
	Mean ± SD (Min-Max)					
A1	00 ±00 (0-0)	0.09 ±0.44 (0-3)	0.09	-1.75	0.08	-0.29
A2	1.15 ±1.21 (0-4)	1.05 ±1.11 (0-5)	0.10	-0.27	0.79	0.09
A3	2.55 ±1.96 (0-7)	2.60 ±2.01 (0-8)	-0.05	-0.15	0.88	-0.03
A4	1.29 ±1.21 (0-6)	1.24 ±1.22 (0-5)	0.05	-0.34	0.74	0.04
A5	2.35 ±1.65 (0-7)	2.11 ±1.94 (0-12)	0.24	-1.06	0.28	0.13
A6	5.64 ±2.39 (1-11)	4.78 ±2.03 (1-11)	0.86	-1.82	0.06	0.39
A7	9.11 ±2.84 (2-14)	7.75 ±2.89 (2-15)	**1.36**	**-2.66**	**0.00**	**0.47**
A8	5.42 ±2.34 (1-10)	4.18 ±2.40 (0-12)	**1.24**	**-2.82**	**0.00**	**0.52**
A9	2.24 ±1.37 (0-6)	1.73 ±1.35 (0-6)	**0.51**	**-1.92**	**0.05**	**0.37**

Note. A – Attack Zones.

Regarding the effectiveness of the winning teams' victories (Table 4), the total number of shots performed in the match was compared to the number of goals scored. Winner teams seems to be more effective than loser teams in all the zones between the 6- and 9-meters lines. Additionally, the results showed that winner teams were more effective in scoring goals through positional and fast attacks, and trough type actions I and II. It is interesting to note that the effectiveness for goals scored trough counter-attack situations and from 7 meters zone were similar between winner and loser teams.

Table 4. 4. Results of the Mann-Whitney U test for the effectiveness of shooting

	Winners (n = 55)	**Losers (n = 55)**	**Different from the winning team**	**Z**	***p***	**d**
	Mean (%) ± SD (Min-Max)					
Total Effectiveness	68.19 ±6.83 (54.55-85.37)	59.41 ±6.33 (44.11-75.60)	**8.78**	**-6.32**	**0.00**	**1.33**
9 meters	46.80 ±13.12 (16.67-71.43)	39.64 ±15.87 (11.11-83.33)	**7.16**	**-2.86**	**0.00**	**0.49**
9 - 6 meters	55.35 ±17.11 (0-83.33)	47.99 ±15.44 (12.50-80)	**7.36**	**-2.53**	**0.01**	**0.45**
6 meters	75.53 ±8.95 (53.57-95)	70.43 ±10.89 (52.63-94.44)	**5.10**	**-2.78**	**0.00**	**0.51**
7 meters	79.95 ±21.94 (0-100)	74.94 ±23.92 (0-100)	5.01	-1.32	0.23	0.22
Defence Zone	78.20 ±38.12 (0-100)	58.89 ±47.50 (0-100)	19.31	-1.06	0.29	0.45
Positional attack	65.55 ±9.03 (44.45-82.86)	56.32 ±8.17 (41.17-75)	**9.23**	**-4.97**	**0.00**	**1.07**
Counter-attack	84.92 ±16.86 (33.34-100)	83.94 ±19.14 (33.33-100)	0.98	-0.16	0.99	0.05
Fast attack	74.75 ±22.50 (0-100)	67.22 ±19.78 (16.67-100)	**7.53**	**-2.53**	**0.01**	**0.36**
Type Action – I	69.67 ±7.26 (55.55-89.28)	61.13 ±7.13 (46.43-77.28)	**8.54**	**-5.40**	**0.00**	**1.19**
Type Action – III	65.28 ±17.83 (16.67-100)	54.23 ±19.87 (16.67-100)	**11.05**	**-3.30**	**0.00**	**0.59**

4.5 Discussion

The aim of the present study was to analyse the differences in the offensive process between winning and losing teams participating in the EHFCL of men's handball. Results showed that the most common offensive method used by the analyzed teams is the positional attack. Nerveless, when in situations of numerical superiority, there exist a tendency to develop more offensive sequences trough situations of counter-attacks and fast attacks (Prieto, 2015).

The only game-action-related variable for which there is a significant difference between winners and losers is the number of assists (which are considered as the final pass before a definite chance at a goal). This performance indicator has been associated in previous studies (Gutiérrez Aguilar & López, 2010; Vuleta et al., 2015), with the winning teams. However, the same authors concluded that counter-attacks are related to

winning, which was not found in the present study. Possibly, the very high level of the sample of this study, which includes teams that are finalists in a European championship, may contribute to the absence of such a marked difference in counter-attack situations.

Goals scored differentiated winners and losers, with specific key indicators being goals scored at 6 meters, situation of match in which there is always a more significant advantage for the attacker (Hatzimanouil, Giatsis, Kepesidou, Kanioglou, & Loizos, 2017). Additionally, winning teams scored more goals during attacks that started with the opponents' defense already fully organised, probably due their superior capacities to resolve offensive problems even against teams well organized in their defense (Ferrari et al., 2014; Rogulj, 2000).

Regarding the goals scored trough Collective Action Type – I, the results showed that winning teams are more balanced than losing teams in all aspects of the offensive. These results are in line with those reported by Ferrari, Vaz, Sousa, Couceiro, and Dias (2018a).

Concerning the finishing zones, the winning teams present higher levels of effectiveness from 6m line, when compared with the losing teams. Additionally, they scored more goals than losing teams from zones A7 (central zone), A8 (lateral area) and A9 (wing zone), which are all close to the 6-meter line on the attacking team's right-hand side. These finding conflicts with the results of Prudente (2006), who found that winning teams scored more goals from the left-hand side.

Shooting effectiveness at 9 meters and at 6 meters, exhibited the largest differences between winners and losers. Vuleta et al. (2015), analysed indicators of team efficiency and also identified shots at 6 meters as a distinguishing factor between winners and losers. Moreover, Meletakos et al. (2011), who evaluated performance indicators at the world championship level, showed a total shot effectiveness of 55% in favour of winning teams, which is well below the levels presented in this study. In this sense, the results of our study seem to show that the analyzed competition presents higher values for the total effectiveness of shots performed by both teams (winners and losers), which is probably due to the high level of the teams observed.

Within the organization of a team, the results showed that winning teams outperformed losing teams in terms of positional attacks and fast attacks. This was also true of effectiveness in Action Collective Type – I and Action Collective Type – III, which are finishing actions originating from a foul at 9 meters and following a shot or a

penalty shot from 7 meters, respectively.

A possible limitation of this study is the fact that the difference in goals at the end of each match was not considered. The introduction of this fact may have been considered in future studies to identify the existence of performance factors associated with balanced vs unbalanced matches as suggested by (Lupo & Tessitore, 2016).

In conclusion, the objective of this investigation was to determine the main indicators that distinguish winning teams from losing teams in European men's club handball using data from games played over the last five years. Differences were found between several performance indicators. Nerveless, the effectiveness of shots was one of the profound differentiators of winning and losing teams.

To the best of our knowledge, this is one of the few studies that includes a multidimensional approach to some performance indicators that have rarely been studied in the past (e.g., shots performed between 6 and 9 meters zone, analysis by type of possession, type of collective actions, etc.) in this sport. In this sense, this study can help coaches and practitioners to extracting more detailed data from the game that may be useful for adapting their training/game processes.

Thus, this study determined that victories are typically achieved by teams that performed better in different aspects of the offensive process and their effectiveness. In this sense, positional attack seems to be the most effective type of play. Therefore, coaches should seek to train situations that create more options and variants in their positional attack to make them increasingly effective. The training of situations of counter-attack and fast attack should not be neglected either, given their importance in certain circumstances of the game.

This study presents a systematic analysis of matches that could be used to adapt the training process in order to improve the performance of teams/players. The profiles of winning teams can help coaches to achieve better sports success by focusing on the indicators detailed in this survey when training their teams. Additionally, this type of systematic analysis, prove to be useful to help coaches (and technical staff) to analyze their own/opponents teams to detected weaknesses/strengths and to adapt specific strategies accordingly.

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Chapter V

Original Study 2

Chapter V

Study 2

The Influence of Tactical and Situational Variables on Offensive Sequences during Elite Handball Matches

Chapter 5. The Influence of Tactical and Situational Variables on Offensive Sequences during Elite Handball Matches

Reference: *Ferrari, W., Sarmento, H., Marques A., Dias, G., Sousa, T., Sanchez P., & Vaz, V. The Influence of Tactical and Situational Variables on Offensive Sequences during Elite Handball Matches. International Journal of Performance Analysis in Sport*

In Review

5.1 Abstract

This study examined the influence of tactical and situational variables on offensive sequences during elite European handball matches. A sample of 55 games and 5,857 offensive sequences from the European Handball Federation Champions League were analyzed using X^2 and logistic regression analyses. Results revealed that positional attacks (odds ratio [OR] = 0.34; 95% CI: 0.28–0.42; p<0.001) and fast attacks (OR = 0.46; 95% CI: 0.36–0.57; p<0.001) decreased the probability of success for an offensive sequence by 66% and 54% when compared with counter-attacks. Offensive sequences that start in the attacking zone seem to be less effective (~78%) than those that start from a situation of "ball in center." Additionally, offensive sequences that finished in the defensive zone of the observed team were 3.19 times more effective than those that ended before the 9m zone. Compared with offensive sequences where the shot is performed from the 9m zone, the chances of an offensive sequence ending successfully are 3.65, 3.60, 2.21 times higher, for offensive sequences where the shot is performed from 7m, 6m, and the defensive zone, respectively. These findings could assist coaches and practitioners in designing specific training situations that improve the effectiveness of the offensive process in handball matches.

KEYWORDS: Notational analysis; Match analysis; Goal scoring; Performance indicators.

5.2 Introduction

The modern game of handball originated in Scandinavia in the early 19th century (Saavedra, 2018). Today, the sport is played by around 19 million people and has been featured in the Olympic Games since 1972. Handball involves many actions—offensive actions include throws, passes, jumps, hits, blocks, pushes, runs, and dribbling (Milanese et al., 2012). Given the complexity of this sport, an athlete's performance in handball depends on multiple factors, such as anthropometric features, coordination, strength, endurance, nutrition, cognition, tactics, social factors, and external influences (Wagner et al., 2014).

Performance analysis in team sports has been part of the agenda of sports scientists for some time now (Ferrari et al., 2019; Sarmento, Clemente et al., 2018; Sarmento et al., 2011), and handball is no exception. Recently, researchers have begun to apply increasingly sophisticated statistical procedures (Almeida et al., 2020) to data sets to understand the factors that promote or hinder offensive effectiveness in handball. Such procedures include network analysis (Korte & Lames, 2019), the classification tree approach (Saavedra et al., 2019), cluster analysis (Gómez-López et al., 2019) polar coordinate analysis (Antonio et al., 2019), and t-patterns analysis (Pic, 2018).

Some of these techniques have been used to investigate the effect of playing tactics on the effectiveness of the offensive process. Offensive tactical activity is a crucial feature of team sports and can be defined as the planned and premeditated management of all offensive systems with the ultimate goal of scoring points (Rogulj et al., 2004). In handball, a scored goal is the result of direct and indirect actions, the use of free spaces, and interactions between players. Additionally, several secondary objectives must be achieved during the different phases of the offensive process to achieve the primary objective of scoring a goal (Gruić et al., 2006).

The observation and analysis of sports have evolved considerably over the past few years due to technological advances. Naturally, the actions that most commonly lead to goals (the main objective of this sport) have been the focus of researchers' attention (Ferrari et al., 2019; Hatzimanouil, 2019; Rogulj, 2000; Rogulj et al., 2011; Vuleta et al., 2005; Zapardiel et al., 2019). This trend is seen in many sports such as football (Armatas et al., 2007; Sarmento, Figueiredo, et al., 2018) and futsal (Sarmento et al., 2016). However, the offensive process in handball has received relatively little attention from

the scientific community.

Nevertheless, available research on male handball provides some useful insights. For example, research has shown that the higher number of goals scored in the second half of games seems to be related to the fatigue experienced by players (Büchel et al., 2019; Povoas et al., 2014) as well as a decrease in the intensity of defensive actions (Skarbalius et al., 2013). Additionally, goals are commonly scored during the last five minutes of each match half (Oliveira et al., 2012) and after time-outs requested by coaches (Prieto, Gómez, Volossovitch et al., 2016).

Furthermore, several researchers have investigated the influence of tactical variables on the efficacy of the offensive process in handball (Alexandru & Acsinte, 2017; Foreti et al., 2013; Prieto, Gómez, & Sampaio, 2016; Rogulj & Srhoj, 2009; Rogulj et al., 2011). Dumangane et al. (2009) concluded that the probability of scoring a goal does not depend directly on the past performance of one's team. Instead, it depends indirectly on the past performance of the opposing team and the difference between the teams' scores during the last ball possession. Additionally, Rogulj et al. (2004) and Rogulj et al. (2011) concluded that teams that made continuous short-term attacks against unorganized defenses, as well as short positional attacks (less than 25 seconds), were more likely to succeed than other teams.

Despite the importance of situational variables on team performance, only a few studies have comprehensively examined such variables (Ferrari et al., 2019; Prieto et al., 2015). Additionally, to provide a contemporary and generalized view of the modern tactics employed by elite handball teams (and the offensive effectiveness associated with them), the influences of additional variables must be analyzed. Therefore, the primary aim of this study is to examine the influence of tactical and situational variables on the success offensive sequences during elite European handball matches.

5.3 Methods

5.3.1 Sample

A sample of 55 games and 5,857 offensive sequences from the European Handball Federation (EHF) Champions League (from 2012/2013 to 2016/2017) were analyzed. The selected teams were classified as the top eight teams in the league based on their final rankings. Matches that ended in a tie were excluded from the analysis. The study was conducted in accordance with the Declaration of Helsinki.

5.3.2 Data Coding System

Data were analyzed using a specific notational system that was developed and validated by Ferrari et al. (2018b). This system combines pitch zones and key offensive activities and subcategorizes them into (1) team possession type; (2) contextual variables; and (3) starting, shooting, and finishing zones.

Table 5. 1. Description of variables and definitions of category used in the team match performance analysis (Team Possession Type, Match Half, Match status, Match outcome, Numerical relationship).

Variables and categories
Team Possession Type
Positional attack - An action is considered when each player occupies their specific position and initiates interactions to move the defense, this phase begins when the opponent's defense is established in their position, against an organized offensive system.
Fast attack - is considered as a second offensive chance, made by later players in the defensive system, who progressed in the field with speed, through quick passes to the attack, to create a situation of superiority or defensive disorganization of the attack to opponents' team
Counter-attack - This offensive method starts in the defensive field, trying to get as fast as possible to the opponents' goal with as few passes as possible.
Type of offensive actions
Complete offensive sequences (OS) - complete collective actions (e.g., start, progression and completion) are those that result from dynamic or static play, implying a start, a progression development in the field of play for more offensive areas and a finalization of the offensive sequence (with or without efficiency).
Set pieces – Actions that start by a stopped ball situation (e.g., 7 meters penalty shot, direct or indirect free kick, foul, etc.) that imply a short finalization and imply a rapid finalization of the offensive process (less than 3 passes between the players).
Match Half
1st half - from the referee's whistle the beginning of the first half to the whistle at the end of this part.
2nd half- from the referee's whistle the beginning of the second half to the whistle at the end of this part.
Match Status – is the current score in which the analyzed action is detected.
Losing > 5 - the observed team has at least 5 or more goals in disadvantage to the opponent
Losing > 3 - the observed team has at least 3 or 4 goals in disadvantage to the opponent
Losing > 1 - the observed team has at least 1 or 2 goals in disadvantage to the opponent
Drawing - the team observed is tied in goals with the opponent
Winning > - 1 the observed team has at least 1 or 2 goals made to advantage to the opponent
Winning > - 3 the observed team has at least 3 or 4 goals made to advantage to the opponent
Winning > - 5 the observed team has at least 5 or more goals made to advantage to the opponent
Match Outcome – is the final score of the game.
Losing > 5 the observed team lost the game by 5 or more goals at a disadvantage to the opponent
Losing > 3 the observed team lost the game by 3 or 4 goals in disadvantage to the opponent
Losing > 1 the observed team lost the game by 1 or 2 goals at a disadvantage to the opponent
Winning > 1 the observed team won the game by at least 1 or 2 goals in advantage to the opponent
Winning > 3 the observed team won the game by at least 3 or 4 goals in advantage to the opponent
Winning > 5 the observed team won the game for at least 5 or more goals in advantage to the opponent
Numerical Relationship
Equality - action in which the teams are equal in number of players in the field
Inferiority - action in which the teams are in numerical inferiority of players in the field
Superiority - action in which the teams are in numerical superiority of players in the field

Table 5. 2. Description of variables and definitions of category used in the team match performance analysis (Starting, shooting and finishing zones).

Variables and categories
Starting zones
Goalkeeper - the team starts the offensive process behind a goalkeeper's defense or a shot outside the goalpost.
Defense - it is characterized by a defensive rebound of the goalkeeper, an interception of the defenders or a foul or technical failure of the opposing team, and the team thus of the beginning with the ball in the zone of the defense.
Attack - starts when the team manages to recover a ball still in the attacking field.
Ball in center - the offensive process starts after the team suffers a goal or start of the first or second part of the game.
Finishing zones
Before 9 meters - any action that was completed before the dashed line of the 9 meters represented in Figure 1 (A1, A2, A3 and A4)
Between 9 - 6 meters - any offensive action that was completed after the 9-meter dashed line represented in Figure 1 (A5, A6, A7, A8 and A9)
Defense zone - any action of the offensive process that has been completed in the zone of defense represented in the figure as all zones containing "D"
Shooting zones
9 meters - The player making the shot has his last support foot placed before the dashed line
9 - 6 meters - the player who hit the ball had his support foot touching the ground, between the dashed line (9 meters) and the 6 meters
6 meters - the player, with his jump, invades the airspace of the area, where he had to finish before landing
7 meters - was carried out while 7 meters penalty shot was awarded
Defense - when the shot was taken from the field of defense of the team.
Effectiveness
With efficiency - shot with a goal scored
Without efficiency - recovery of ball possession by the opponent, ball out, violation of the rules of the game, shot defended by the goalkeeper, shot out, shot into the opponent.

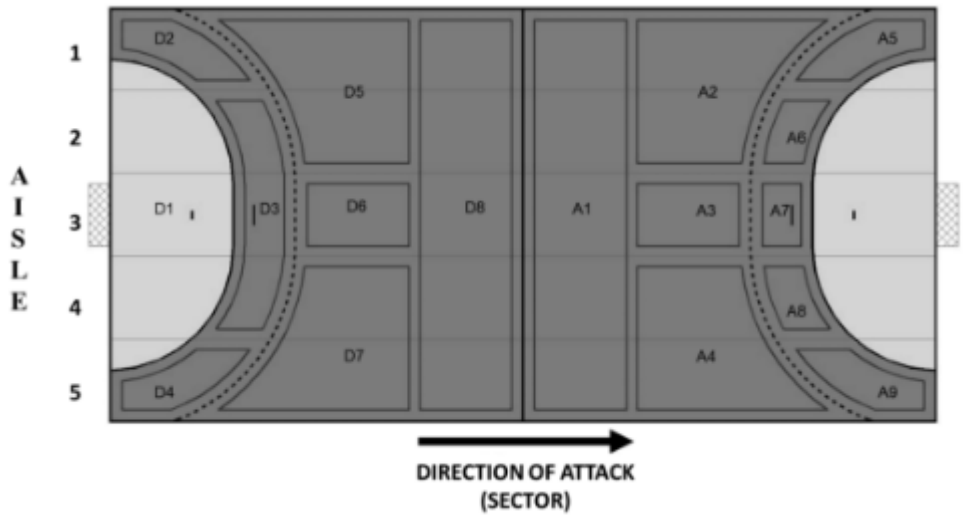

Figure 5. 1. Field zones

Note. *D – References the Defensive Zones; A – References the Offensive Zones*

Two handball analysts experienced in match analysis procedures used this observational instrument tool to analyze offensive sequences. After a training period, each analyst analyzed six randomly selected games (corresponding to 10.9% of the sample). Based on their analyses, intraobserver reliability was assessed using the offensive sequences of the same six games. The lead author of this study then repeated these on two occasions four weeks later.

5.3.3 Statistical Analyses

All analyses were performed using statistical software (IBM SPSS, version 24.0). Intraobserver and interobserver agreement (Table 3) were quantified using Cohen's kappa (Cohen, 1960). The statistical analysis was implemented in two stages. In the first stage, an X^2 analysis was performed to determine whether either type of independent variable (playing tactics and situational variables) was associated with the probability of producing an effective offensive sequence. In the second stage, a logistic regression analysis was performed to examine the independent and interactive effects of all independent variables. The statistical model employed involved reverse hierarchical elimination (Kleinbaum, Dietz, Gail, Klein, & Klein, 2002). An alpha value of <0.05 was used for all statistical tests.

Table 5. 3. Kappa values for intraobserver and interobserver.

	Intraobserver		**Interobserver**	
Variable	**Kappa**	**CI (95%)**	**Kappa**	**CI (95%)**
Type of attack	0.92	0.91 – 0.94	0.91	0.88 – 0.93
Match Half	0.99	0.98 – 0.99	0.99	0.98 – 0.99
Starting zones	0.88	0.86 – 0.90	0.89	0.86 – 0.91
Shooting zones	0.90	0.88 – 0.92	0.90	0.87 – 0.92
End zones	0.90	0.87 – 0.94	0.89	0.86 – 0.93
Numerical Relationship	0.91	0.89 – 0.93	0.90	0.87 – 0.92

5.4 Results

A total of 5,857 offensive sequences were analyzed (52.24% with effectiveness) in the following subsets: (1) positional attacks (n=4428), fast attacks (n=854), counter-attacks, (n=575). Differences were observed in the probability of producing effective offensive

sequences for all variables except for the main variable of "match status" (Table 4).

Differences were also found between the different "types of attack" in terms of whether they produced an effective offensive sequence. In this sense, positional attacks (odds ratio [OR] = 0.34; 95% CI: 0.28–0.42; p<0.001) and fast attacks (OR = 0.46; 95% CI: 0.36–0.57; p<0.001) decreased the probability of success by 66% and 54% when compared with counter-attacks.

Additionally, the type of offensive sequence seems to influence the efficacy of offensive sequences. Elaborate offensive sequences tend to be more effective than short ones that result from a direct/indirect free kick or a 7m penalty shot (OR = 0.78; 95% CI: 0.61–0.98; p=0.043).

Furthermore, teams losing by more than five goals were 1.67 times more likely (95% CI: 1.20-2.33; p<0.002) to perform a successful offensive sequence when compared with teams losing by more than one goal. Also, teams winning by more than five goals had a 44% weaker chance (OR = 0.66; 95% CI: 0.44–0.99; p<0.001) of performing a successful offensive sequence when compared with teams losing by more than one goal.

Additionally, the probability of producing an effective offensive sequence is 1.5 times higher (95% CI: 1.11-2.03; p=.008) for a team that is winning a game by more than five goals when compared to a team that is losing by one or two goals. When a team is losing by more than 3 or more than 5 goals, their likelihood of performing a successful offensive sequence reduces by 33% (OR = 0.67; 95% CI: 0.51–0.90; p=0.007) and 46% (OR = 0.54; 95% CI: 0.39–0.75; p<0.001), respectively, when compared with teams losing by more than one goal.

Table 5. 4. Differences in possession outcome according to playing tactics and situational variables.

Variables	Without effectiveness, n (%)	With effectiveness, n (%)	OR (95% CI)	*p*
Type of Attack				0.001**
Counter-attack	152 (26.4)	423 (73.6)	1.00 (ref.)	
Positional Attack	2268 (51.2)	2160 (48.8)	0.34 (0.28-0.42)	0.001**
Fast Attack	377 (44.1)	477 (55.9)	0.46 (0.36-0.57)	0.001**
Type of offensive actions				0.001**
Complete OS	1340 (34.8)	2510 (65.2)	1.00 (ref.)	
Set Pieces	356 (39.3)	550 (60.7)	0.78 (0.61-0.98)	0.037*
Match Half				0.334
1st half	1378 (48.4)	1468 (51.6)	1.00 (ref.)	
2nd half	1387 (47.2)	1553 (52.8)	1.00 (0.86-1.16)	0.964
Match Status				0.249
Drawing	485 (49.4)	497 (50.6)	1.00 (ref.)	
Losing > 1	365 (48.5)	387 (51.5)	1.03 (0.79-1.34)	0.851
Losing > 3	634 (47.2)	709 (52.8)	1.15 (0.91-1.47)	0.242
Losing > 5	264 (47.1)	297 (52.9)	1.67 (1.20-2.33)	0.002**
Winning > 1	297 (45.2)	360 (54.8)	1.06 (0.80-1.40)	0.698
Winning > 3	595 (49.6)	604 (50.4)	0.81 (0.63-1.05)	0.108
Winning > 5	157 (43.3)	206 (56.7)	0.66 (0.44-0.99)	0.043*
Match outcome				0.001**
Losing > 1	256 (47.7)	281 (52.3)	1.00 (ref.)	
Losing > 3	683 (49.7)	690 (50.3)	0.67 (0.51-0.90)	0.007**
Losing > 5	568 (55.8)	450 (44.2)	0.54 (0.39-0.75)	0.000**
Winning > 1	249 (46.4)	288 (53.6)	0.78 (0.55-1.09)	0.144
Winning > 3	571 (46.3)	661 (53.7)	1.04 (0.78-1.38)	0.806
Winning > 5	470 (40.5)	690 (59.5)	1.50 (1.11-2.03)	0.008**

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

Additional differences were observed regarding the odds ratio for producing effective offensive sequences based on the zone of the field where the offensive process starts. Offensive sequences that started from the attacking zones were less effective (~78%) than those that started from a situation of "ball in center." Furthermore, the results revealed that offensive sequences that finished in the defensive zone of the observed team were 3.19 times more effective (95% CI: 1.94-5.25; $p<0.001$) than those that ended before the 9m zone (offensive midfielder).

Differences in offensive sequences were also found based on the finishing zone of the field. When compared with offensive sequences in which the shot was performed

from 9m zone, the chance of an offensive sequence ending successfully is 3.65 higher (95% CI: 2.84-4.69; p<0.001), 3.60 times higher (95% CI: 3.10-4.19; p<0.001), and 2.21 times higher (95% CI: 1.09-4.49; p=0.028) when the shot is performed from 9m, 6m, and defensive zones, respectively.

For the main variable of "numerical relationship," the chances of an offensive sequence ending successfully is 1.38 times higher when the observed team has numerical superiority (95% CI: 1.09–1.75; p=0.007), whereas having fewer players on the field decreases the chances of performing a successful offensive sequence by 36% (95% CI: 0.47–0.87; p=0.004).

Table 5. 5. Differences in possession outcome according to start, finishing and shooting zones and numerical relationship.

Variables	Without effectiveness, n (%)	With effectiveness, n (%)	OR (95% CI)	*p*
Starting Zone				0.001**
Ball in centre	1613 (50.8)	1561 (49.2)	1.00 (ref.)	
Goalkeeper	601 (48.0)	652 (52.0)	0.94 (0.78-1.14)	0.527
Defence	579 (40.7)	845 (59.3)	1.08 (0.89-1.33)	0.429
Attack	4 (66.7)	2 (33.3)	0.22 (0.04-1.29)	0.093
Finishing zones				0.001**
Before 9 meters	1051 (65.8)	548 (34.2)	1.00 (ref.)	
Between 9 – 6 meters	1696 (40.5)	2491 (59.5)	1.13 (0.68-1.87)	0.637
Defence zone	50 (68.5)	23 (31.5)	3.19 (1.94-5.25)	0.001**
Shooting Zones				0.001**
9 m	628 (53.6)	544 (46.4)	1.00 (ref.)	
9 – 6 m	421 (44.8)	519 (55.2)	1.42 (1.20-1.69)	0.001**
6 m	530 (24.3)	1655 (75.7)	3.60 (3.10-4.19)	0.001**
7 m	101 (24.0)	319 (76.0)	3.65 (2.84-4.69)	0.001**
Defence	12 (34.3)	23 (65.7)	2.21 (1.09-4.49)	0.028*
Numerical relationship				0.001**
Equality	2297 (47.9)	2503 (52.1)	1.00 (ref.)	
Inferiority	193 (59.8)	130 (40.2)	0.64 (0.47-0.87)	0.004**
Superiority	307 (41.8)	427 (58.2)	1.38 (1.09-1.75)	0.007**

Note. *** p<0.01 *p<0.05*

The odds ratios presented indicate that a one-second increase in the duration of an offensive sequence causes a 1% decrease (OR = 0.99; 95% CI: 0.98–0.99; p<0.001) in the probability that the outcome will be successful. Additionally, an extra pass increases the probability of success (OR = 1.03; 95% CI: 1.01–1.05; p=0.008).

Table 5. 6. Differences in possession outcome according the duration and total of passes.

Variables	Without goal n (%)	With Goal n (%)	OR (95% CI)	*p*
Time of duration	36.35 (35.58-37.13)	32.33 (31.57-33.08)	0.99 (0.98-0.99)	0.001**
Total of passes	13.10 (12.82-13.37)	11.66 (11.39-11.94)	1.03 (1.01-1.05)	0.008**

Note. *** p<0.01*

5.5 Discussion

To the best of our knowledge, this is the first study to explore the combined effects of tactics and situational factors concerning offensive effectiveness among teams in the EHF Champions League.

Regarding tactics, elite handball teams playing mostly in positional attacks (Foreti et al., 2013; Gutiérrez Aguilar & Ruiz, 2013; Rogulj et al., 2004). In terms of team possession type, differences in the probability of efficacy depended on the specificities of offensive sequences. The traditional debate about what style of play is most effective has been debated by researchers in handball and other sports for a long time (Lago-Peñas, 2009; Sarmento, Figueiredo et al., 2018). Counter-attacks seem to be the offensive sequences that have the most efficacy in handball, as is the case in other sports, such as football. The "fast type" of attacks (counter-attacks and positional attacks) appear to promote success due to their sudden execution and the quick transition from defending to attacking while the opponent's defense is unbalanced (Dumangane et al., 2009; Rogulj et al., 2004; Ruiz Sánchez et al., 2017).

Nevertheless, our results reveal that elaborate offensive sequences (i.e., those resulting from positional attacks, counter-attacks, or positional attacks) seem to be more effective than shorter sequences (e.g., situations resulting from a dead ball; those involving no more than three passes; or those resulting from a 7m penalty shot, a 9m direct/indirect free kick, etc.). Although this might seem to contradict previous results, this situation is plausible because in situations that start with a dead ball, the opposing defense can organize itself to prevent a successful attack. As stated in previous research, these types of situations significantly influence the outcomes of matches (Ferrari et al.,

2018a).

Concerning situational variables, match status has a direct influence on the probability that a team will end an offensive sequence by scoring a goal. Teams losing by more than five goals had a 1.67 times greater chance of performing a successful offensive sequence than teams losing by more than one goal. Conversely, teams winning by more than five goals were 44% less likely to perform a successful offensive sequence than teams losing by more than one goal.

This could be the case because teams slow their pace when they are winning by several goals (Debanne & Laffaye, 2015; Molfetas et al., 2019), as they tend to focus more on maintaining their advantage than increasing it (Dumangane et al., 2009). Sometimes, having a comfortable advantage in a match can increase the confidence of the leading team; however, this can lead to overconfidence, which causes some devolution among the leading team and favors the efficiency of the trailing team (Schinke et al., 2018).

The zones of the field in which an offensive sequence starts seems to influence the sequence's outcome. Offensive sequences that start in an attacking zone are less effective (~78%) than those that start in a situation of "ball in center." As is the case with offensive actions resulting from dead balls, this result could be because the opponent has an opportunity to organize their defense before the sequence begins. However, these data should be analyzed with some caution due to the small number of occurrences recorded. The main variable of interest ("finishing zones") did not influence the zone of the field where the offensive sequence ends in the offensive midfield (before 9 meters vs. 6-9 meters) relative to their efficacy. This result was unexpected because previous research indicates that offensive sequences that end in zones closer to the goal have greater efficacy (Hatzimanouil, 2019; Volossovitch et al., 2003).

Concerning offensive sequences that end with a shot on goal, our results confirmed that 7m penalty shots have the highest level of efficacy. Previous studies demonstrate that a team's effectiveness in these types of situations is crucial to match outcomes (Daza et al., 2017; Vuleta et al., 2012). Excluding 7m penalty shots, the most effective zone for finishing an offensive sequence seems to be the 6m zone. The efficacy of teams in these situations is also considered a meaningful performance indicator that distinguishes winning teams from losing teams in balanced game contexts (Foretić et al., 2010; Gruić et al., 2006; Meletakos et al., 2011; Srhoj et al., 2001; Teles & Volossovitch,

2015).

The difference between shots taken from the 6m zone and shots taken from the 9m zone in terms of their efficacy has not been studied in depth prior to the present work. The data presented in this study is significant, considering that most of the offensive sequences that end in a shot in handball end in these zones. This study's differentiated analysis of the areas where shots are taken from has been necessary for a long time due to changes in the rules of the game (Ferrari et al., 2018b; Skarbalius & Krusinskiene, 2003). A particularly interesting result emerged from the analysis. Shots performed from the defensive zone that provide a chance for an offensive sequence were 2.21 times more likely to succeed than offensive sequences in which the shot is performed from the 9m zone. This result reflects the effectiveness of teams in taking advantage of the temporary defensive disorganization of the opposing team, especially when the team is playing without their goalkeeper in the goal.

Concerning the numerical relationship between teams, we concluded that the chance of an offensive sequence ending successfully is 1.38 times higher when the observed team has a numerical advantage, whereas having fewer players on the field leads to a 36% decrease in the success rate of offensive sequences. In this sense, there seems to be a clear benefit to the teams that take advantage of situations when they have numerical superiority due to a two-minute sanction imposed on a player of the opposing team (Fasold & Redlich, 2018; Gryko et al., 2018).

The multiple regression analysis revealed that long possessions (in terms of the number of the passes performed) were more effective than short possessions. Specifically, an extra pass increases the probability that the offensive sequence will be successful by 1.03 times. However, this is only true when the extra pass does not increase the duration of the offensive sequence, as a one-second increase in the duration of an offensive sequence decreases the probability of success by 1%. These results corroborate previous findings in the context of handball (Ferrari et al., 2016; Ferreira et al., 2018; Gutiérrez Aguilar & López, 2010).

Many variables seem to impact the performance of handball teams. Nevertheless, a significant challenge remains, and more research needs to be conducted to analyze the obstacles that teams need to overcome while attacking in the most effective way possible (Sarmento, Figueiredo, et al., 2018). Therefore, the present paper provides valuable insights to coaches and sports scientists, as it provides some essential generalizations that

can be applied in elite handball.

5.6 Conclusion

The data presented in this study demonstrates some useful findings regarding the success of offensive sequences in elite European handball teams. These data could provide valuable information for coaches and practitioners to consider when designing training exercises to promote players' abilities in specific situations. These situations should include: i) counter-attacks as one of the privileged types of attacks; ii) more detailed training for set pieces since they tend to be less effective than the complete sequences of the offensive process; iii) situations in which the match status is unbalanced, as this will improve the players' concentration; iv) training exercises with the goal of entering the zone between 6-9 meters, especially those that encourage players to take shots from the 6m zone; and v) short offensive sequences involving many passes.

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Chapter VI

Original Study 3

Chapter VI

Study 3

Handball offensive analysis: comparative evolution of linear tendency lines between finalist teams in EHFCL

Chapter 6. Handball offensive analysis: comparative evolution of linear tendency lines between finalist teams in EHFCL

Reference: *Ferrari, W., Dias, G., Sarmento, H., Sousa, T., Couceiro M., & Vaz, V., Handball Offensive Analysis: Comparative Evolution of Linear Tendency Lines Between Finalist Teams in EHFCL, South African Journal for Research in Sport, Physical Education and Recreation*

In Review

6.1 Abstract

This study aims to show the evolution of the finalist teams in 5 years of the EHF Champions League and compares winning with defeated teams, showing their evolution along the competition from the quarterfinals to the final. In this study we analysed 35 games, corresponding to four games per team along five seasons (2012 to 2017). Tendency lines were created according to the 13 offensive indicators of winning teams, divided into three macro categories: i) game actions; ii) goals, and iii) effectiveness of shots. The results show 21 linear tendency lines valid for the study. Winning teams presented five increasing lines (positive slope) and 16 decreasing lines (negative slope) during the competition. Assists (m= 1.05), goals at 6 meters (m= 1.03) and effectiveness at 6-meter shots (m= 1.50) presented increasing tendency line for the winning teams and the effectiveness of goals (m= -0.47), the effectiveness of the organised attack (m= -0.74) and the effectiveness of shots of 9-6 meters (m= -1.30) presented a decreasing tendency line. However, winning teams have more regularity during the competition. Due to the expected increased difficulty in successive matches, tendency lines tend to present decreasing slope as one advances towards the final. Nevertheless, the winning teams need to adapt to the increasing challenge, describing growth in some key indicators, being more regular than others.

Keywords: Game analysis; Performance analysis; EHFCL analysis.

6.2 Introduction

Handball is different from most of the collective sports. It was not created, it has evolved from games of the antique Greece and Germany to the game practised today (Rodrigues, 2017). Handball was played by 11 players per team and in an outdoor field. It evolved to seven players per team game in the 1960's, on indoor courts (Meletakos & Bayios, 2010).

The complexity of the game, the constant difficulty in evaluating the performance of teams and athletes and the constant search for answers that can contribute to the improvement of the game make the organization, in charge of handball, always try to adapt and modify the game in order to make it more efficient, seeking a constant evolution in terms of processes and dynamics (Prudente, 2006; Sousa, Prudente, Sequeira, López-López, & Hernández-Mendo, 2015).

Performance analysis in handball aims to provide an opportunity to predict the result of the game, in order to be well prepared for future competitive scenarios (Volossovitch, 2013). Knowledge of the indicators that describe performance in team sports is a determining factor for coaches' decision making when planning training and during matches (Gomez, Lago-Penas, Viano, & Gonzalez-Garcia, 2014; Lago-Penas, Gomez, Viano, Gonzalez-Garcia, & Fernandez-Villarino, 2013; Prieto, Gómez, Volossovitch, & Sampaio, 2016). The analysis of the handball matches during the main competitions is becoming an essential factor that influences the focus of the training programs and the content of the training units (Balint, 2012; Gomez et al., 2014)

To better understand and interpret the outcome of a match, it is necessary to focus on a type of analysis that allows an understanding of the relationships between the factors that lead to victory (Karastergios, Skandalis, Zapartidis, & Hatzimanouil, 2017; Volossovitch, 2005). To find a model, Debanne and Laffaye (2017) showed that it is possible to use relevant variables to predict the winner and the loser of a handball match and their difference of goals by applying a multiple regression model, using data from the German and French championships.

Longitudinal studies are used to understand changes in the game, using the same sample in all data collections (Matthys et al., 2013). In handball match analysis, researchers use longitudinal studies to create a pattern or evolution of teams over the years (Bilge, 2012; Espina-Agulló, Pérez-Turpin, Jiménez-Olmedo, Penichet-Tomás, & Pueo, 2016; Meletakos & Bayios, 2010). Determining the evolution of games' actions after a

certain period can emphasise the development tendency of the handball match (Alexandru & Acsinte, 2017).

Several other studies in handball try to identify why teams are successful, making the comparison between winners and losers (Ferrari, Vaz, & Valente-dos-Santos, 2014; Gutiérrez Aguilar & López, 2010; Saavedra, Þorgeirsson, Kristjánsdóttir, Chang, & Halldórsson, 2017; Skarbalius, Pukėnas, & Vidūnaitė, 2013; Vuleta, Sporiš, & Milanović, 2015). Thus, the tendency lines aim to show how winning teams evolve during a competition within the determined success indicators, whether constant, growing or descending.

In the pursuit of identifying the evolution of teams, Alexandru and Acsinte (2017) make a comparison with the evolution of teams in the European championship in two consecutive years, with the primary variable of the study being the number of goals scored. This allowed to know the evolution of each team, observing the tendency to improve the game and the way each team has adapted to the particularities of its players, the international conception of games and the way of training.

Ferreira Filho, Sousa, and Greco (2001) observed and evaluated handball matches from 1986 to 1995, in a total of 19 games, to thereby diagnose the level of technical-tactical performance of handball teams and compare the performance levels of teams in world championship and Olympic games, and fond that was evolution in the performance parameters. The authors Vuleta et al. (2015) suggest in their research that it is necessary to follow the tendency of the match of handball and its constant changes in certain variables.

Gryko, Bodasiński, Bodasińska, and Zieliński (2018), in their study, assess the tendency of the teams in two competitive years of the world championship (2013 and 2015). Their main conclusions were that the analysis of this cycle revealed changes in the characteristics of the offensive game, that they should have an impact in the specific training so that the team's game actions are closer to the opponents' goal area, where multi-player actions are fundamental to the successful performance in the game and evidenced by the tendency observed in handball over the last few years (Bilge, 2012; Czerwinski, 2000).

A linear tendency line is a straight line of best fit used with simple linear data sets. The tendency line method in sports was used by Mendes et al. (2013), using to measure the variability of the tennis players' services. Furthermore, Skarbalius et al. (2013) make

a comparison between the several years and noticed an evolution between the variable of goals scored by the teams between the years of 2002 and 2010 of the European championship of handball. Finally, Ferrari, Vaz, Sousa, Couceiro, and Dias (2018) make a comparison between the French men's teams world champions in seniors and juniors, showing the progression of the team during the championship from the quarter-final to the final match, within the offensive variables of the match of handball.

Hence, this study aims to perform a comparative analysis of the offensive behaviour and determine the game patterns of the finalist teams as they evolved during competition in the EHF CL according to the analysed seasons, using as a basis the linear trends lines.

6.3 Methods

This study will include a descriptive analysis of the key indicators of the quarterfinals (4 matches) and the semi-final (2 matches) and final (1 match) of the EHF Champions League finalists in 5 seasons (n = 35), respectively 2012-2013, 2013-2014, 2014-2015, 2015-2016 and 2016-2017, considering the averages of the finalists, making a comparison between the winning team and the losing teams.

The variables used in this study were stipulated according to Ferrari, Vaz, Sousa, Sarmento, & Dias, 2018. They determined the variables that differentiate the winners from the losers during the same season mentioned above. The same authors identified 13 key indicators for the winning teams, in match variables, and divided them into 3 categories: the offensive actions, goals and effectiveness of shoots.

The matches were analysed using the *VideObserver*®, and hereafter the data was exported to a spreadsheet in Microsoft Excel 2016 for Windows®. Then, we realised a third-order exponential function (Mendes et al., 2013), aiming to determine the linear trends of the teams, according to the variables considered determinant for the success of the teams in the games observed. In this way, it is observed the slope of the line, defined as variable m (matrix), indicating whether it was increasing (positive slope) or decreasing (negative slope), or if it was constant, thus allowing analysing the linear tendency performance of the respective teams (Ferrari, Vaz, Sousa, Couceiro et al., 2018; Skarbalius et al., 2013).

In order to better understand the results, the value of the coefficient of

determination (R^2) is used which indicates in percentage how much the model can explain the observed values, using Pearson's correlation to measure the degree (Gomes, Volossovitch, & Ferreira, 2014; Gomez et al., 2014; Guzmán, Calpe-Gomez, Grijalbo Santamaria, & Imfeld Burkhard, 2012).

For the reliability of the observation of the evaluated matches, intraobserver and interobserver agreement was used in all the criteria, it was stipulated by the index de Kappa de Cohen (Cohen, 1960; Prudente, Sousa, Sequeira, Lopez-Lopez, & Hernandez-Mendo, 2017), which was higher than 0.87.

6.4 Results

The results were divided according to the offensive actions, goals and effectiveness of the finalist teams during the five seasons and within those analysed periods, there was never the same winning team, showing the difficulty encountered by the teams in the EHF CL. The teams are divided by countries: with two German teams (2012-2013 and 2013-2014), a Spanish team (2014-2015), a Polish team (2015-2016) and a Macedonian team (2016-2017). The teams that were in second place are teams from Spain (2012-2013), Germany (2013-2014), France (2016-2017), and the same team from Hungary was twice ranked in second (2014-2015 and 2015-2016).

6.4.1 Offensive Actions and Goals

Assists is the only variable that presents significant values for the two teams. They both have a strong correlation (75%) in the evolution of the championship and they both present values in a growing line. Also, in increasing amounts, the winning teams have goals scored at 6 meters showing a very strong correlation (95%).

The defeated teams show a decreasing tendency line in total of goals (m = -0.9 very strong correlation 99%) and goals in collective actions Type-I (m = -1.2 strong correlation 87%), the winning teams do not have any negative lines and the goal in positioned attack also shows no tendency (Table 6.1).

Table 6. 1. Descriptive analysis of offensive actions performed in matches.

Variables	Year	Quarterfinals	Semi-finals	Finals	m	R^2
Assists	Winners	8.10	10.20	10.20	1.05	0.75**
	Losers	7.71	8.20	8.20	0.24	0.75**
Total Goals	Winners	29	33.40	30.20	0.6	0.06
	Losers	30	29.20	28.20	-0.9	0.99***
Goals Action Type – I	Winners	22	28.60	25.40	1.7	0.26
	Losers	25	23	22.60	-1.2	0.87**
Goals Attack Positioned	Winners	20.60	25.20	21.40	0.4	0.02
	Losers	20.43	17.80	20.20	-0.11	0.00
Goals 6m	Winners	16.20	18	18.80	1.3	0.95***
	Losers	14.57	17.20	13.40	-0.5	0.09

Note. *m= Matrix; * Moderate correlation; ** Strong correlation; *** Very strong correlation*

The lines of tendency on the assists made by the teams during the competition present the two teams with a growing line, but the line of the winning team compared to the defeated team shows a higher inclination which demonstrates a greater evolution during the competition of the winner's teams (Figure 6.1).

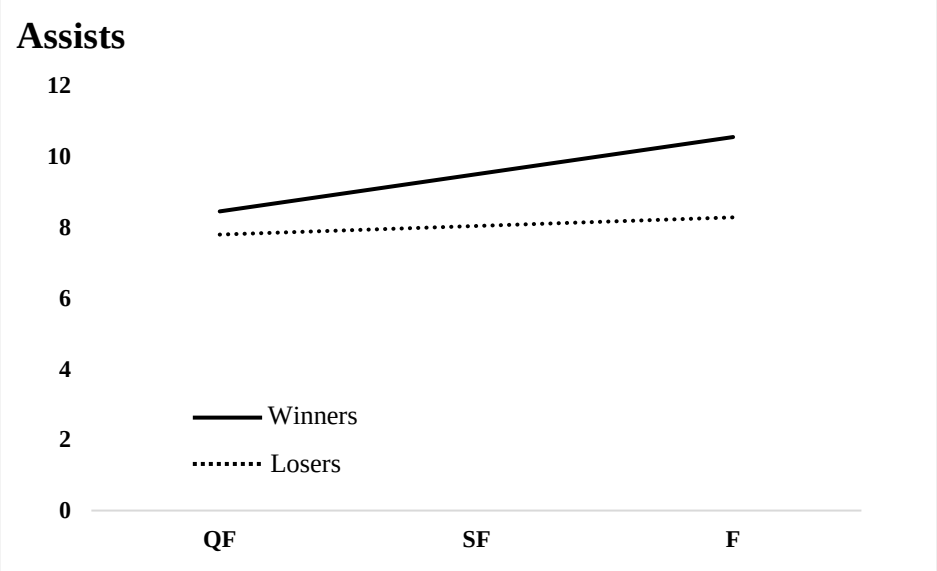

Figure 6. 1. Linear tendency lines of assists performed in matches.
Note. QF= Quarterfinals; SF= Semi-Finals; F= Finals

In Figure 6.2 both group of teams have very close results in the quarterfinals, but with the development of the competition the winning teams always show a more significant evolution than the teams defeated mainly regarding the total of goals and the goals in 6 meters. As to goals in collective actions Type - I and in the positioned attack, the teams are shown to be more balanced and with the lines of tendencies closer.

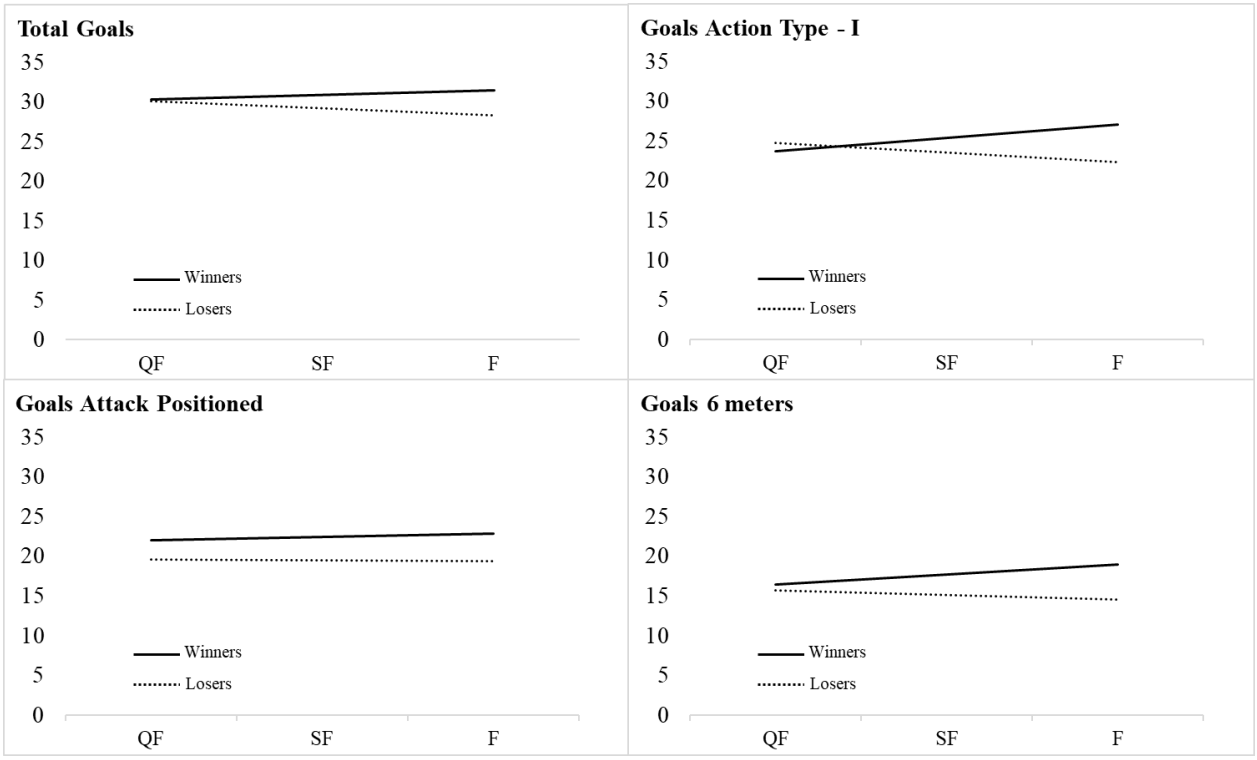

Figure 6. 2. Linear tendency lines of goals
Note. QF= Quarterfinals; SF= Semi-Finals; F= Finals

6.4.2 Effectiveness of shooting

To be considered the effectiveness of the shots was counted only by the complete shots if there were technical or tactical errors the shots were not counted. In Table 6.2, the winning teams present a growing tendency line in the effectiveness of collective actions Type – I (m = 1.37 strong correlation 73%) and efficacy in shots at 6 meters (m = 1.50 moderate correlation 51%), the loser's teams do not show any increasing tendency line in shooting effectiveness.

In Table 6.2 there is a large majority of negative tendency lines due to the increase in the degree of difficulty during the evolution of the competition. The winning teams decrease their effectiveness of collective actions Type – III (m = -11.41 strong correlation 88%), effectiveness of organized attack (m = -0.74 strong correlation 80%) and fast attack (m = -2.85 very strong correlation 96%) on effectiveness of goals (m = -0.47 strong correlation 80%), effectiveness on shots at 9 meters m = -5.88 strong correlation 78%) and shots between 9 and 6 meters (m = -1.30 strong correlation 78%).

The defeated teams exhibit a tendency line in efficiency always negative in all analysed variables, in collective actions Type – I (m = -4.51 very strong correlation 94%),

in collective actions Type – III (m = -3.94 moderate correlation 56%), efficacy in the organized attack (m = -4.80 strong correlation 76%) and fast attack (m = -2.77 very strong correlation 92%) in the effectiveness of goals (m = -4.78 very strong correlation 99%), shots at 9 meters (m = -2.02 very strong correlation 91%), shots between 9 and 6 meters (m = -7.14 strong correlation 78%) and shots at 6 meters (m = -4.67 moderate correlation 52%).

Table 6. 2. Descriptive analysis of effectiveness of shooting performed in matches.

Variables		**Quarterfinals**	**Semi-finals**	**Finals**	**m**	**R^2**
Action Type – I	Winners	66.53	69.21	69.17	1.37	0.73**
	Losers	72.67	66.29	63.63	-4.51	0.94***
Action Type – III	Winners	68.08	63.51	62.12	-11.41	0.88**
	Losers	65.64	67.70	57.76	-3.94	0.56*
Goals Attack Positioned	Winners	63.61	63.51	62.12	-0.74	0.80**
	Losers	67.48	58.09	57.88	-4.80	0.76**
Goals Fast Attack	Winners	79.75	77.90	74.05	-2.85	0.96***
	Losers	75.03	70.89	69.43	-2.77	0.92***
Goals	Winners	66.39	66.32	65.43	-0.47	0.80**
	Losers	70.71	65.57	61.15	-4.78	0.99***
9 meters	Winners	47.43	46.91	35.67	-5.88	0.78**
	Losers	55.49	52.42	51.44	-2.02	0.91***
9 – 6 meters	Winners	55.23	52.74	56.61	-1.30	0.78**
	Losers	65.24	54.43	50.94	-7.14	0.91***
6 meters	Winners	72.74	71.67	75.67	1.50	0.51*
	Losers	76.28	79.42	66.43	-4.67	0.52*

Note. m= matrix * Moderate correlation; ** Strong correlation; *** Very strong correlation

The results presented in the tendency lines of Figure 6.3 show that the effectiveness of the teams has always been very close, forming two very similar lines, the winning team only demonstrates a growing line in effectiveness in shots in collective actions Type – I. As to the effectiveness of shooting in organized attack and fast attack, the winning teams present a tendency line superior to the defeated teams, and even when there is a slope in the line, it is inferior to the declivity in the line of the defeated teams. The opposite is shown in the effectiveness of the collective actions Type – III, where the slope of the winning teams' line is much higher in comparison to the defeated teams.

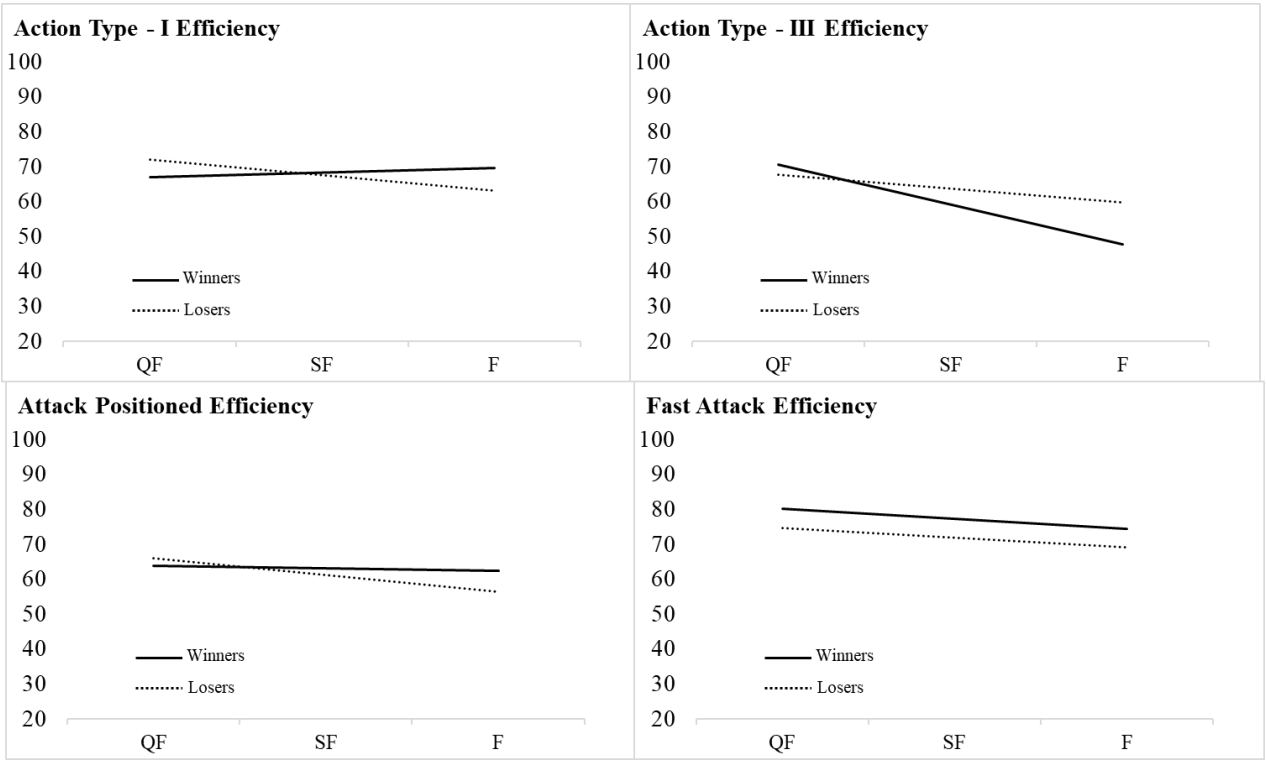

Figure 6. 3. Linear tendency lines of the effectiveness of game action
Note. QF= Quarterfinals; SF= Semi-Finals; F= Finals

In Figure 6.4, the effectiveness of the completed shots shows the most dispersed tendency lines where the teams present the most significant discrepancies between them. The defeated teams exhibit a higher average in all variables analysed in the quarter-finals of the EHF CL, but with the evolution to the final they tend to decrease their effectiveness of shots and to exhibit a much higher slope than the winning teams, being the effectiveness of shots and goals, the effectiveness of shots between 9 and 6 meters and the shots at 6 meters. Only in the effectiveness of the shots at 9 meters, the defeated teams present better results than the winning teams.

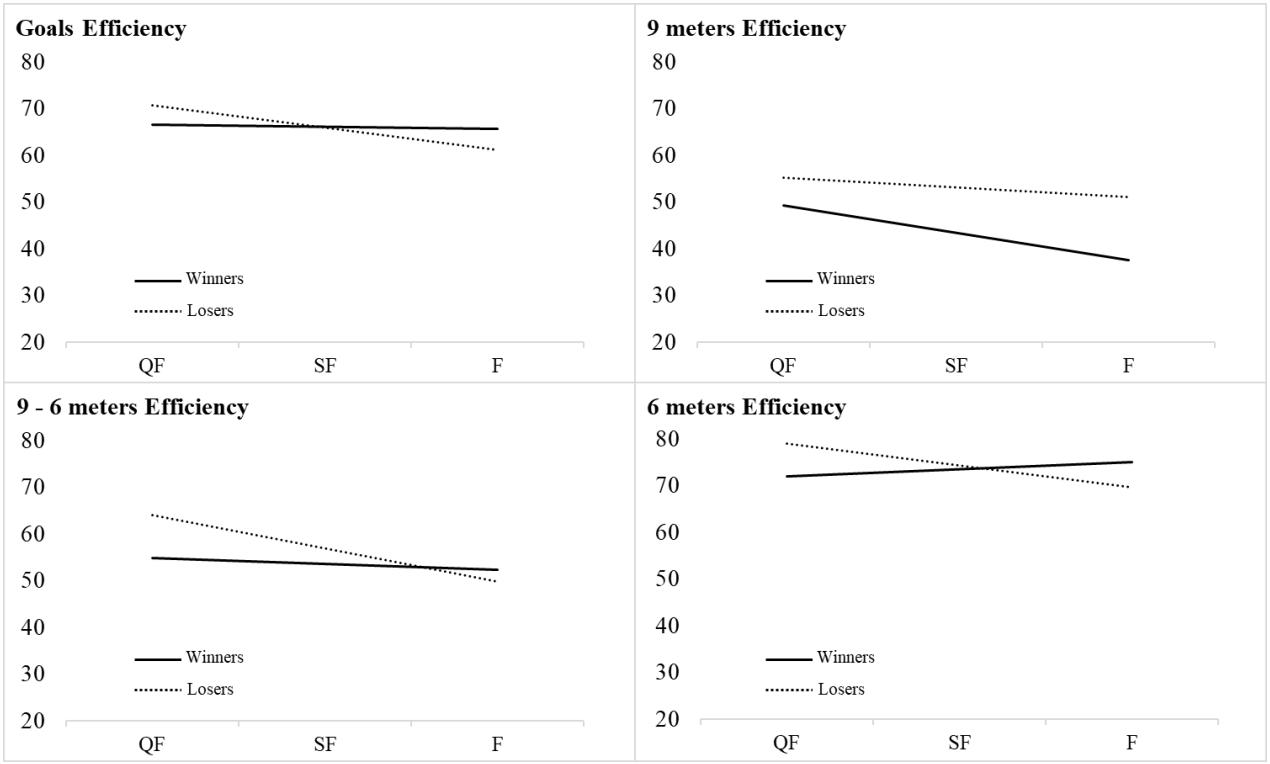

Figure 6. 4. Linear tendency lines of the effectiveness of shooting
Note. QF= Quarterfinals; SF= Semi-Finals; F= Finals

When we evaluate the linear tendency lines of the teams in a total of 26 tendency lines, we find that 21 lines of tendencies are statistically valid according to Pearson's correlation, that is, 80% of the total sample of the tendency lines are valid. Of these 21 lines valid for the study, 5 present an ascending slope, with the team presenting an evolution during the championship in this final phase of the competition, and 16 present a negative evolution of the team due to a higher difficulty found in the final phase of the competition.

6.5 Discussion

The analysis of linear tendency is necessary to show the evolution of the finalist teams (Ferrari, Vaz, Sousa, Couceiro et al., 2018) during the championship and to draw a perspective on where the team improves or worsens within the key performance indicators and a comparison between the winning teams and the defeated teams.

The evaluation of the assists appears as a critical factor in the growth of the teams during the competition, showing a more significant interaction between the players and the decision making in demand of the easier shot to be performed, the assistance being

considered the final pass for the accomplishment of the shot, when the opponent doesn't have the capacity to intervene between the shooter and the goalkeeper. The tendency line of this same variable shows a superiority of the winning teams in relation to the defeated ones in the growth of the straight line (m =1.05 winners; m= 0.24 losers) and the values of the means, confirming the studies of Bajgorić, Rogulj, Čavala, and Burger (2017) successful teams have a higher number of assists compared to those that have less success.

The total goals scored by the teams tend to decrease with the teams confronting adversaries with a higher degree of difficulty and with the more balanced games between teams in an advance stage of the competition. Ferreira Filho et al. (2001) note that, throughout the years, there is a natural tendency for goals to decrease during the evolution of the championship, as the teams are more organised defensively, causing a greater balance between them and more being used by defensive specialists. This explains the increase in the number of goals scored at 6 meters by the winning teams, evidenced in the tendency line (m = 1.3 very strong correlation 95%), because there are more goal assists and players are always looking for the best option for the shot, being the closest possible to the goal (6 meters) makes the shot easier for goal conversion (Hatzimanouil, Giatsis, Kepesidou, Kanioglou, & Loizos, 2017).

As to The collective actions type – I, which are the offensive actions that demonstrate a beginning, a progression and a finalization, defeated teams showed lower tendency lines with less goals scored than the winning teams (Figure 6.2), which shows a decrease in the evolution of the competition (m = -1.2 losers), contrary to Ferrari, Vaz, Sousa, Couceiro, et al. (2018), where teams display values that show an increase in collective actions of type – I, during the initial course until the end of the championship.

The effectiveness of the shooting was the category that most differentiated the winners from the losers (Ferrari et al., 2014; Vuleta et al., 2015) and is the one that shows more reliability of the tendency lines, where all the lines were considered valid. In the efficacy of collective actions of Type – I, the winning team presents a positive tendency line (m = 1.37), the opposite of the defeated team (m = -4.51 very strong correlation 94%), which shows a slope in the tendency line. In the efficacy of the collective actions type – III, the two teams present a decreasing in the tendency line. However, the winning team is in a much more significant decreasing line than the defeated teams (m = -11.41 winners, m = -3.94 losers), very similar to the study of Ferrari, Vaz, Sousa, Couceiro et al. (2018) which also shows a larger declivity for the team that was successful in the competition.

A very similar tendency line is verified in the effectiveness of the organised attack presented in the graph that demonstrates two lines of negative tendencies, but the winning team's line (m = -0.74) shows a much smaller slope compared to the defeated (m = -4.80): a difference of -4.06 between the two teams. Concerning the effectiveness of the goals in fast attack, the finalist teams also show a similar decreasing in the tendency lines (m = -2.85 winners very strong correlation 96%; m = -2.77 losers very strong correlation 92%) being the average values of effectiveness of the winning team on a higher level than the defeated teams. Regarding the effectiveness of the total goals scored, the finalists show a decrease during the evolution of the championship (Ferreira Filho et al., 2001), but the winning teams show a greater regularity during the matches where it is close to reaching a straight line (m = -0.74) different from the defeated teams. They start with a higher effectiveness than the winning teams but during the course of the competition the tendency line shows a very accentuated decrease in the total effectiveness of shots (m = -4.78 very strong correlation 99%).

The 9-meters efficacy variable is the only key indicator in which defeated teams have a higher average compared to winning teams from the beginning of the competition to the end, even though both teams have negative values in the tendency lines (m = -5.08 winners, m = -2.02 losers very strong correlation 91%). These figures are explained by Gryko et al. (2018) who in their study confirm that there is a decrease in the efficiency of the shots in the 9 meters during the course of the competitions, mainly in comparison to the winners and losers. As to the effectiveness of shots made between 9 - 6 meters, the finalists also show a decreasing in the tendency line, but again the winning teams show a more regular average than the defeated teams (m = -1.30 winners; -7.14 losers very strong correlation 91%), showing that the comparison between the teams ends up being made regularity throughout the competition, taking into account that the average of the defeated teams starts higher in comparison with the winning team, but in the end the winning team stays more regular until the final game.

The most significant difference in the efficiency of the shots between the teams analysed is in the shots at 6 meters: the winning team once again starts with a lower average than the team that won in the quarterfinals and the course of the competition increases its average and presents a positive tendency line (m = 1.50). The opposite occurs with the defeated team showing a higher average than the winning teams, but in the course of the competition they will decrease (m = -4.67). Thus, the studies of Gryko et al. (2018);

Srhoj, Rogulj, and Katić (2001) define that the effectiveness of the shots at 6 meters tend to increase during the final phase of the competition for the winning teams.

When comparing the winning and defeated finalist teams there are only five tendency lines that appear in a growing line. Four of them are related to the winning teams, showing that even with the greatest difficulty found in the games the winning teams were able to evolve in four key indicators during the competition, different from the teams defeated that only achieved to evolve in one of the variables of success of the game.

Of the 21 tendency lines considered valid for this study, there is clear evidence that the teams during the competition will decrease the success of their offensive actions, efficiency and goals scored, due to the increase of difficulties encountered in the course of the competition passing from the quarter-finals to the final. So those 16 tendency lines appear on a declivity, which means that teams have reduced their ability to develop the key indicators of the offensive game process due to the increased difficulty in the games, having to develop more challenging attack solutions. The winning teams are more regular and do not have a tendency line with such an accentuated declivity, especially in the key variables of the game that differentiate the winning teams from the losers.

6.6 Conclusion

The objective of the study is to identify the evolution of the finalist teams during the competition, to compare the team averages in the competitive years analysed and the offensive behaviour of the teams in the EHFCL by comparing with the winning team and the second-place team. The teams always have the objective to evolve during the final phase of the championship to reach a goal that in this case is winning the championship. However, linear tendency lines help differentiate those teams. As they evolve in competition, they tend to decrease attack effectiveness and have more difficulty in overcoming the opposing defence, with winning teams needing to adapt to the new difficulties encountered in the game in each competitive phase, adopting to be as regular as possible within these successful indicators that differentiate the winners from the losers.

In comparison with the finalists, it is verified that assists and goals at 6 meters and effectiveness at the 6-meter shots are the key success indicators of the winning teams,

being the only variables where the teams maintained a growing line throughout the final phase of the competition. The goal effectiveness, organised attack effectiveness, and effectiveness of 9-6-meter shots, while indicating a decreasing tendency line, winning teams show a line close to a straight line, demonstrating great regularity throughout the competition in these key indicators for the success of the winning teams.

Finally, coaches want their teams to evolve and increase their quality of play during the competition, reducing mistakes and increasing their collective performance to overcome the difficulties of the games and have a higher probability of obtaining the sport success, being essential that coaches think about the purpose of their training plan so that their teams can overcome the difficulties imposed by future opponents.

This study ends up being limited due to the method used for the research to be recent and to the deficiency of the literature in the field of linear tendency lines used in a game analysis and leaving as future suggestions a more advanced and more extended analysis using all matches of the competition to have the actual behaviour of the winning teams throughout the entire competitive trajectory.

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Chapter VII

General Discussion and Conclusion

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7.1 General Discussion and Conclusions

According to Garganta (2009), the most correct strategy, when confronting opponents, has in the analysis of the game the important tool that allows to have a clear view of the behaviour of a team during a match and to determine its possibility in the game. Therefore, our results suggest that players' interactive behaviors within a handball match support the existence of an individual contributions to the collective team performance. These data are in line with Cloe et al. (2001), Sampaio and Janeira (2003) and Seabra (2010), as the analysis methodologies lead to the discovery of individual and collective performance during competition. Moreover, our results can be used to characterize the collective behaviors emerging through the cooperation between players during handball matches. So, the overall performance should be understood in terms of self-organizing system, interaction dynamics and relationships established among players, considering the different stages of the match, as well as the type of relationships established (Ferrari et al., 2020).

On the other hand, understanding the behaviour patterns that happen from the various game situations is an important idea in understanding the handball game. In our investigation, we verified the importance of the studies presented, and reverted in articles in peer-reviewed journals, aimed at investigating the offensive process in elite teams. However, the literature on match analysis in handball is still scarce and concentrated mostly in a few variables of performance. Moreover, the existing handball performance analysis database is insufficient to allow coaches and match analysts to establish performance optimization measures (Ferrrari et al., 2020).

Overall, our results showed that the macro categories include an offensive variable that was applied to handball for the first time, specifically, for the case of collective actions: Type I, Type II and Type III. These collective actions have already been applied to soccer and roller hockey, in studies published by Gama et al. (2014), Vaz et al. (2014) and Vázquez (1998). Thus, the great variability of collective actions (Type I, Type II and Type III) implies that interpersonal interactions can change from match to match, considering the different moments of the competition.

In the case of handball match analysis, studies using the dynamic approach have used a diversity of analysis methods to evaluate the performance during the match. In this way, we will facilitate a more profitable relationship between science and practice,

enhancing the collaboration between coaches and scientists (Ferrari et al., 2019). So, handball performance can be considered as a “dynamic system”, with great complexity and variability. Hence, this study provides a multidimensional analysis of the handball match, clarifying how a competitive match requires performers to co-adapt to teammate behaviors. This approach may help coaches in assessing the interactions of (intra and inter-individual) players and the team (Ferrari et al., 2020).

In line with Prudente et al. (2017), our results explain how the score and playing time influences the efficiency of the actions, taking into account the tendencies in the evolution of the match. Consequently, for the same authors (2017), offensive, defensive and goalkeeper threshold indicators can be a guide to players and coaches to assess the match. So, the “success” of an offensive action during a match of handball depends (also) on the capacity of teams and individuals to adjust their actions to the variations in the offensive perspective of the game.

Finally, the application of trend lines, which intends to determine the linear tendencies of the teams, according to the variables considered determinant for the success of the teams in the observed games (see Ferrari et al., 2018), was another contribution used in sport in general, and in handball in particular, that originated the “final product” of this study.

Given the above, the next section provides an in-depth discussion of the theoretical implications and methodological value of the key findings reported.

7.2 Theoretical and methodological considerations

Findings from all three experimental studies have consistently revealed how players interact mutually at different levels of organization in the offensive process. The differentiation between successful teams in handball is a central principle of an analytical approach to the game (Debanne, Laffaye, & Trouilloud, 2018; Dimitrios, 2019; Gryko, Bodasiński, Bodasińska, & Zieliński, 2018; Vuleta, Sporiš, & Milanović, 2015). However, there are few examples of game analysis in the main European club competition available in the research literature.

With one exception: Leuciuc and Dariusz (2018) make a descriptive analysis of the results obtained only in the "Final 4" of the European Handball Federation (EHF) Champions League. Most of the studies focused on international championships of

national teams, mainly European Championships, World Championships and/or Olympic Games (Gruić, Vuleta, & Milanović, 2006; Gryko et al., 2018; Hansen et al., 2017; Konstantinos, Elissavet, Panagiotis, Ioannis, & Konstantinos, 2018; Leuciuc, 2017; Leuciuc & Pricop, 2015; Milanović, Vuleta, & Ohnjec, 2018) and national leagues (Bajgorić, Rogulj, Čavala, & Burger, 2017; Gomes, Volossovitch, & Ferreira, 2018; Gutiérrez Aguilar & López, 2010; Meletakos & Bayios, 2010; Rogulj, Srhoj, & Srhoj, 2004; Rogulj, Vuleta, Milanovic, Cavala, & Foretic, 2011).

In view of Chapter 2, further analysis of performance in handball is still necessary (Prieto, Gómez, & Sampaio, 2015). With more resources, the methodology of analysis is considered necessary to create an extended database in order to cover adequately a broad set of situations that occur in the game of handball. It can be observed that most articles focused on the study of offensive actions. Shooting was the main study variable, having been considered the different positions on the field, shooting distance and game situations. Likewise, several relevant studies have analysed the differences between winning teams and losing teams, differences in the location of the game and the effect of coaching timeouts on the game.

The research in sports performance analysis, in particular, game analysis, has evolved over the years, mainly due to the tremendous technological advances that make the researchers' task easier since they have access to videos of games that allow a more detailed analysis of the game (Román, 2015). Besides, the validation provided by experts in the sport, presented in chapter 3, introduces the definitions of several authors, which allowed to construct an instrument of analysis that distinguishes the key indicators that characterize the typology of offensive games of the teams in handball.

The uses of observational methodology, techniques of the sequential analysis, in particular, offer new possibilities in the observation and analysis of the behaviours of teams (Amatria, Lapresa, Martín Santos, & Pérez Turpin, 2020). Thus, it is possible to capture information about the conducts that allow an analysis of regularities, as well as to understand how they induce or inhibit other conducts, based on a probabilistic reading of the occurrence of events.

The data in chapters 4 and 5 showed how the effectiveness of the winning teams and the offensive actions of the game itself share the same success goals, demonstrating the importance of increasing fast actions (Bajgorić et al., 2017) and shooting in attack as

near as possible to the opposing goal (Gruić et al., 2006; Leuciuc & Pricop, 2015), thus inducing more difficulty to opponent defences (Elena, 2013; Fasold & Redlich, 2018) and goalkeepers (Hatzimanouil, Giatsis, Kepesidou, Kanioglou, & Loizos, 2017; Weber, van Maanen-Coppens, & Wegner, 2018).

The analysis of performance in handball is usually carried out in a quantitative perspective, analysing the number of successful and unsuccessful actions in the playing field areas, either individually or collectively (Prudente, 2006). The importance of the tactical-technical indicators in the evaluation of performance in handball are used in a reducing way to quantify the performance of the teams, constituting the results obtained for the definition of indicative average values for excellent sport performance (Paula et al., 2020).

The evolution of the handball game and its analyses are documented (Alexandru & Acsinte, 2017; Espina-Agulló, Pérez-Turpin, Jiménez-Olmedo, Penichet-Tomás, & Pueo, 2016; Ferreira Filho, Sousa, & Greco, 2001; Román, 2015) according to various criteria from the evolution of a team or a particular type of release until the evolution of the game and in chapter 6 it is evident the difficulty found by teams in advancing throughout the competition. When teams reach a final and the "home" factor is no longer present, teams lose that influence which is one of the determining factors for the success of teams in sport (Nevill & Holder, 1999) and in handball in particular (Lago-Penas, Gomez, Viano, Gonzalez-Garcia, & Fernandez-Villarino, 2013; Pic, 2018).

An evolution of these analyses, based on the perception that in the handball, they detect player actions emerge in function of the opponents and the cooperation with the members of their own team (Almeida, Merlin, Pinto, Torres, & Cunha, 2020). To realize the analysis of a dynamic social phenomenon such as the handball game, it is necessary to ensure a data collection that allows reconstructing the film of the events in totality.

All the conceptual and methodological advances presented in this thesis will undoubtedly serve as the basis for the future reinforcement of this work program, as well as a basis for possible practical applications discussed in the next section.

7.2.1 Learning and training design

Chapter 3 precisely gives rise to a new nomenclature for game situations that were not previously exploited and adapted from other sports, such as collective actions that prove to be key indicators for team success. As well as the successful shots between 9

and 6 meters that demonstrate many differences in statistical terms, opening a new perspective on finishing areas and giving a better understanding about the types of shooting and their real effect in the game (Skarbalius & Krusinskiene, 2003; Skarbalius, Pukėnas, & Vidūnaitė, 2013).

Specifically, during game development, to obtain winning teams as quoted in chapter 4, coaches should consider using tactics to try to improve the performance of their teams in the various phases of the game, in order to achieve greater control of the game and obtain the highest possible difference on the scoreboard, or the least disadvantage possible in relation to the opponent. Coaches of elite handball teams may apply the methodology described in Chapter 4 to conduct specific analyses of offensive game patterns of both their teams and their opponents in order to decipher the specific punctuation dynamics of each team more accurately.

Following up on the team success study, Chapter 5 provided some practical information on the effectiveness of successful actions in handball teams, and therefore the training aspects should focus on the specific preparation for a team capable of carrying out faster attacks that are more collectively complete, without forgetting the other phases of the game. Specifically, during game development, coaches should remind their players about specific moves trained for each game context and, within the practical tasks, simulate changes and add performance constraints can be a useful strategy to improve team adaptability and prevent they surprises (Vargas, 2003).

This adaptability is evident in Chapter 6: using an evolutionary approach, coaches make it essential, so that in their training plan they pay attention to the difficulties imposed by the opponents and always make the team evolve in search of success. It is essential to design tasks that continuously evolve and require related decisions and actions among players to regulate their collective behaviours and thus achieve their performance goals (Araujo, Davids, & Passos, 2007; Davids, 2014).

Another important application of the results of these studies is the creation of an evaluation model and the application of software that can be used by the coaches to evaluate the situational efficiency of the teams in a match and during the season. Another is to establish the form of competition of players as basis for the formation of the game plan, to program and to realize the process of sports preparation aimed at the improvement of the performance.

7.2.2 Performance analysis

Practical implications of this thesis can be extended to the field of performance analysis. Incorporate the use of real-time video-based multiplayer tracking systems to analyse the scoring processes of the two teams could help identify the actions of players that trigger specific patterns of in-game scoring. Further analysis of these actions with players can help improve their performance in these specific situations.

Currently, most professional handball clubs use technology as a routine procedure in performance analysis (Mavridis, Tsamourtzis, Salonikidis, & Michaltsi, 2006) both in physical aspect and game analysis. However, the analysis is almost always based on the physical work rates required for the players or the simple descriptive game statistics. The same rough data can be used to compute meaningful information about individual and team behaviours and improve the understanding of performance at a new level.

Therefore, new measurement tools, such as those proposed in Chapter 3, or others used in the experimental studies of this thesis, will undoubtedly contribute to a better understanding of team performance. Using these measurement tools can allow accurate monitoring of training and competition, just as coaches can be told whether teams are expressing the type of strategies or behaviours they are following during practice sessions.

For example, does the team assume the values that your coach would like to have in-game contexts? What is the relationship between the finishing areas of the team during the attack phases? Also, how does this influence the synchronization of players' movements in the transition from defence to attack? What kind of differences does a team show on two opposing teams with different characteristics and rating levels? The proposed measuring instruments and, more broadly, the whole methodology underlying these analyses can help to answer these types of practical questions.

7.3 Conceptual model derived from findings

To better integrate all findings of the current thesis, Figure 7.1 proposes a model that shows how different levels of game analysis can be integrated and conceptualized in terms of the game's functional variability and their performance constraints imposed on team success.

In this conceptual model it is possible to identify and evaluate the performance of successful teams thus developing a cycle where the main object is the offensive process and to correlate to dependencies of all the different processes used during the thesis. From the outset, it was important to identify everything that was covered in handball and fill in the gaps that appear as the game develops, creating an instrument that allows us to assess all the developments that occurred.

Cycle of conceptual model of analisys in handball

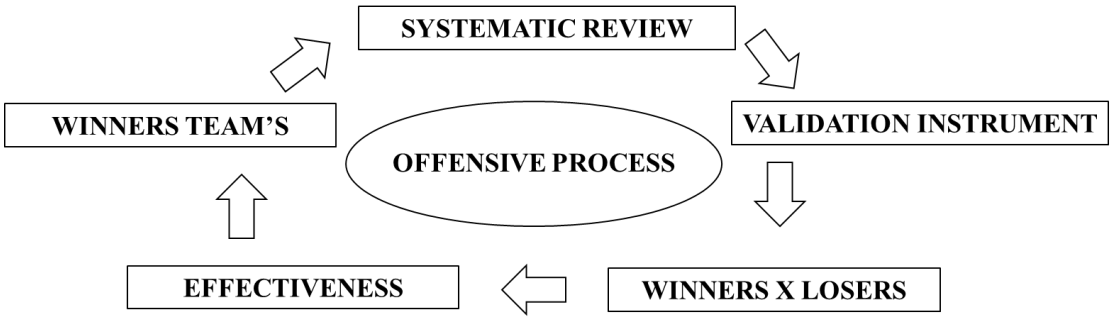

Figure 7.1. A conceptual model, of association in handball analysis performance derived from the experimental findings of the current thesis.

To identify the actions that make teams succeed within the game (Chapter 4), we have to consider the main features: assists, goals at 6 meters and offensive effectiveness. Follow that the basic principle of handball match is to score goals, the most effective model (Chapter 5) is to identify the offensive process as a whole. Like the 6-meter shots, the quick attacks are considered as both counter-attacks and quick transition attacks until the end of the cycle to create a model for analysing the teams that have won the competition as they progressed throughout the competition until reaching the final, where the teams exhibited the evolution in terms of assists, effectiveness and goals at 6 meters that were identified in previous studies (Chapter 6).

Like the studies of Prudente (2006) which thoroughly analyze the game regarding the technique and tactics in the game itself, in a sequential manner and Prieto (2015) who uses the same cyclical model of analysis, more encompassed for the specific analysis of game moments that may decide the advantage for a team. All with similar models of the analysis process, with the difference in the central research objective (Saavedra & Saavedra, 2020).

7.4 Future research perspectives

The end of a cycle, as noted above, is the beginning of new challenges central to game analysis. This section attempts to frame some future perspectives in this field of research. Some research needs to be done to enable the transfer of knowledge to coaches, performance analysts, and handball practitioners in general. Handball analysis generally needs some measurement tools that must be combined and integrated into a single software application, allowing rapid and almost automatic generation of results to aid and inform the decisions of coaches and athletes, as well as improve training analysis.

On the other hand, scientific knowledge commonly advances through successive approaches. Three theoretical-methodological questions derived from this thesis will be the object of further exploration. The first is the differentiation between winners and losers, and many authors have been working on these issues of success in different sports and not only in handball. Within handball, the issues that remain to be developed are not the questioning about the offensive process and the defensive process imposed by the teams.

Many have studied the ability of the goalkeeper to be a differentiating factor (Hansen et al., 2017; Hatzimanouil et al., 2017), and other studies comprise the defensive ability of the teams in conjunction with the offensive ability (Gryko et al., 2018; Leuciuc & Pricop, 2015), but there is no study delimiting the defensive systems in their approaches and transformations (6:0; 5:1; 3:3, 5+1, etc.) and how they influence the success or non-success of teams. In elite teams there is a more and more defensive specialist and little or nothing is studied about this differential, about the influence that player or more players who are defensive experts have on the overall effectiveness of the team.

The second question covers the offensive effectiveness of teams because to quantify the outcome of the end of the action is not enough. It is important to analyse how this action developed throughout the process from the beginning of team possession until the end of the play and determine which were the indicators of success that were necessary for this team to obtain the success of this action. Some surveys in the area of network are being developed in order to track the success of actions (Hassan, 2014; Hassan, Schrapf, Ramadan, & Tilp, 2017; Mavridis, Florêncio, Ben Shitrit, Fua, & Fonseca, 2013), but

little is studied about the movement of the athlete without the ball, and their defensive imbalances caused in the opposing teams, as well as the decision making of the athlete who has the ball and the athlete without the ball, which are determining factors in the success of an offensive action. Moreover, so can have a better understanding of the offensive process and its effectiveness.

The third question concerns the evolutionary analysis of handball. Researches in this area of knowledge reveal to be quite vast or about handball as a whole. (Alexandru & Acsinte, 2017; Curiţianu & Neamţu, 2014). The tendency lines are a new approach that end up creating a more robust line on how teams end up developing. This methodology still has much scope to be explored and developed in order to contribute to the development of the teams. More advanced and more extended analysis using all matches of the competition to have the actual behaviour of the winning teams along the competitive trajectory are situations to be further explored by researchers.

The general guidelines for future work on handball match analysis include, but are not limited to: i) comparing winning teams throughout sporting seasons; ii) understanding the effects of major indicators in different match periods; iii) understanding evolutionary tendencies of the match during several times iv) conducting more studies focused on the defensive profile, v) analysing international club competitions; vi) analysing video matches and not using other reports provided by the tournament organization; vii) using standardized variables for all researchers. In this sense, there is a need to promote the development of systems for analysing the performance of athletes and teams that allow continuous and sequential mapping of actions occurring in the game. In this way, we will facilitate a more profitable relationship between science and practice, enhancing the collaboration between coaches and scientists. So, coaches want their teams to evolve and increase their quality of play during the competition, reducing mistakes and increasing their collective performance to overcome the difficulties of the games and having a higher probability of obtaining the sport success, being essential that the coaches think about the purpose of their training plan so that their teams can overcome the difficulties imposed by future opponents. (Ferrari, Vaz, Dias, Gama, Sousa, & Couceiro, 2016).

We also consider that in the future, research should be carried out in the analysis of offensive actions when using samples of youth handball to identify potential

differences between professional and base handball in the competitive contexts studied, giving a higher amplitude in handball game analysis.

It is probable that adaptations to these models can be successfully applied to capture the evolutionary dynamics of handball teams as functionally integrated entities or "super-organisms." For example, modelling specific game behaviours, such as a team defending its own goal, while the other team uses the passing game for a considerable time to destabilize the positioning of opponents. This task could potentially reveal how specific attack teams could exploit certain spaces provided by opponents or inform defenders about the most effective defensive behaviours to be adopted against specific team formations with certain prevailing game patterns. This can be an important advance for the analysis of sports performance, allowing accurate simulations and predictions about the collective behaviour of teams.

7.5. Limitations of the study

Limitations of the reviewed studies are related to the default definitions of terms and conflicting expressions of activities and actions, which make it difficult to compare a similar group of studies. The use of studies with teams of different levels and different national championships also complicated the standardization of conditioned groups, thus hindering a replication of the studies and their future comparisons.

A possible limitation of this study is the fact that the difference in goals at the end of each match was not considered. The introduction of this factor may have to be taken into account in future studies in order to identify the existence of performance factors associated with balanced vs unbalanced matches as suggested by Lupo and Tessitore (2016).

This study ends up being limited due to the method used for the research to be recent and to the deficiency of the literature in the field of linear tendency lines used in a game analysis and leaving as future suggestions a more advanced and more extended analysis using all matches of the competition to have the actual behaviour of the winning teams throughout the entire competitive trajectory.

7.6 Practical implications

To the best of our knowledge, this is one of the few studies that includes a multidimensional approach to some performance indicators that have rarely been studied in the past in this sport. In this sense, this study can help coaches and practitioners to extract more detailed data from the game that may be useful for adapting their training/game processes. These outcomes could assist coaches and practitioners in designing specific training situations that improve the effectiveness of the offensive process in handball matches.

On the other hand, our study could provide valuable information for coaches and practitioners to consider when designing training exercises to promote players' abilities in specific situations.

Our study indicated that winning teams performed better regarding the variables that defined the effectiveness of offensive shots, especially successful positioned attacks and fast attacks. They also had a greater number of assists. So, profiles of the most successful teams can help coaches and practitioners to achieve better performances adjusting the training process according the performance indicators that seem to lead more often to success.

This study determined that victories are typically achieved by teams that performed better in different aspects of the offensive process and their effectiveness. In this sense, positional attack seems to be the most effective type of play. Therefore, coaches should seek to train situations that create more options and variants in their positional attack to make them increasingly effective. The training of situations of counter-attack and fast attack should not be neglected either, given their importance in certain circumstances of the game.

The profiles of winning teams can help coaches to achieve better sports success by focusing on the indicators detailed in this survey when training their teams. Additionally, this type of systematic analysis proves to be useful to help coaches (and technical staff) to analyze their own / the opponents' teams to detect weaknesses/strengths and to adapt specific strategies accordingly.

Finally, our study allows coaches to observe a possible relation between structural behaviours of the game, something that might contribute, regarding practical applications, to the optimisation of the sports performance individually and collectively.

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