



# Match Analysis in Handball: A Systematic Review

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**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.

**KEY WORDS** game analysis, performance, teams' sports, PRISMA



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MATCH ANALYSIS IN HANDBALL

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## 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; Czerwinski & Taborsky, 1996; 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 (A. Silva & Anzano, 2018; J. Silva, 2008; Valeria et al., 2017; Zapardiel Cortés, Ferragut Fiol, Manchado, Abalde Valeiras, & Vila Suárez, 2017), football (Kempe & Memmert, 2018; McKenna, Cowan, Stevenson, & Baker, 2018; Yang, Leicht, Lago, & Gomez, 2018), basketball (Clemente, Gonzalez-Villora, Delextrat, Martins, & Vicedo, 2017; Conte, Favero, Niederhausen, Capranica, & Tessitore, 2017) and other sports (Kempton, Sirotic, & Coutts, 2017; Sarmiento et al., 2016; Valhondo, Fernandez-Echeverria, Gonzalez-Silva, Claver, & Moreno, 2018).

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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 (Sarmiento, Anguera, Pereira, & Araújo, 2018; Sarmiento et al., 2014), volleyball (M. Silva, Marcelino, Lacerda, & João, 2016), futsal (Abras, Ferragut, & Abalde, 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 researches in this area, their methodologies, and the tendency of evolution for future projects.

## Methods

### *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: (1) contain relevant data concerning technical and tactical evaluation or statistical compilation, and time-motion analysis; (2) performed by amateur and/or professional adult male handball players and (3) written in the English language. Studies were excluded if they: (1) included children or adolescents; (2) included females; (3) did not include relevant data for this study, and (4) 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).

### *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).

## Results

### *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 1).

After in-depth analysis, it was decided that the most appropriate way to present the results would be to categorize them as suggested (Sarmiento 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).

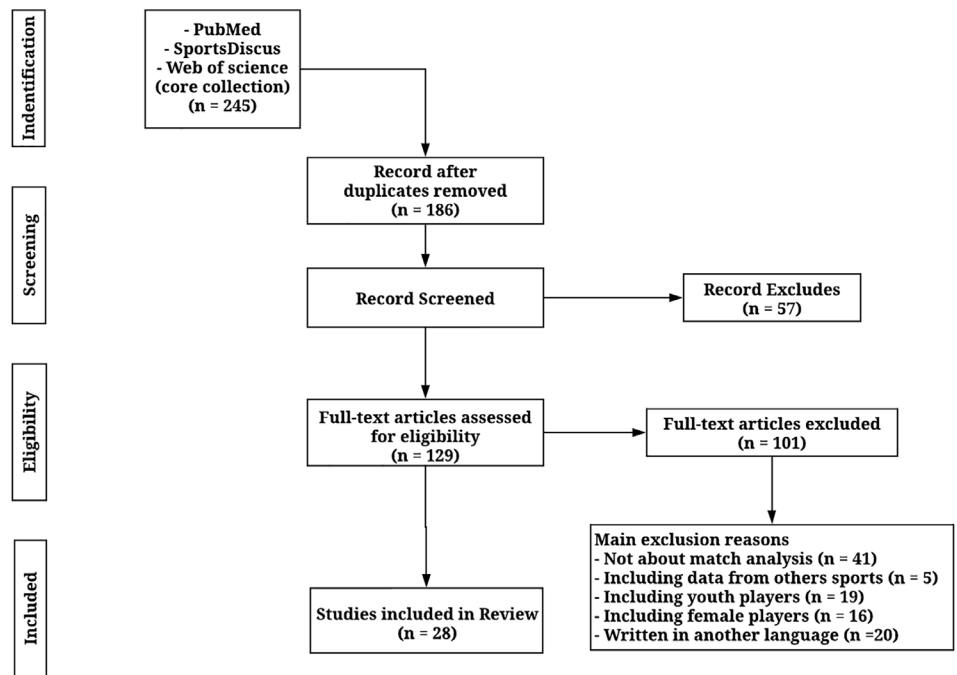


FIGURE 1 Preferred report items for systematic review flow diagram

**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.

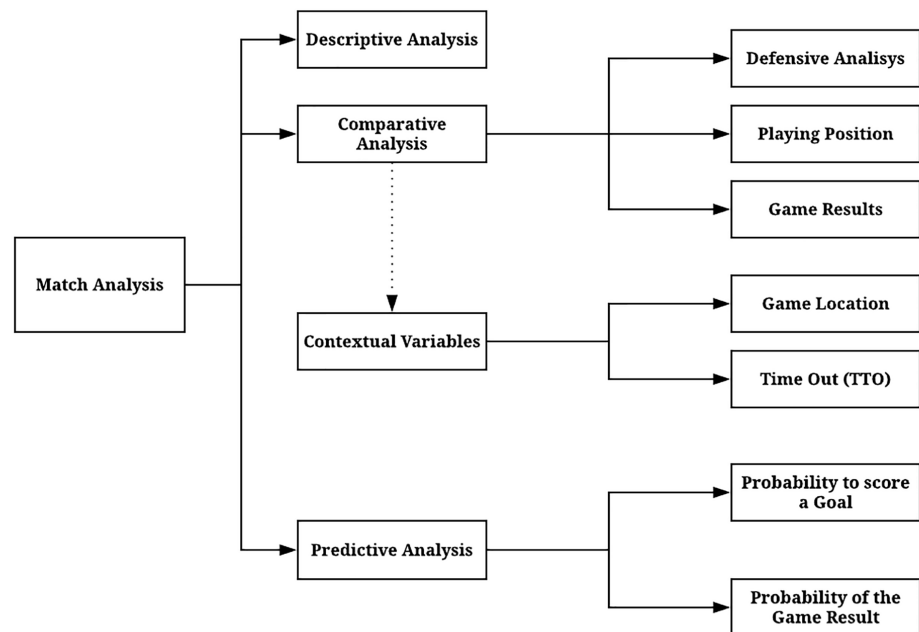


FIGURE 2 Scopes of match analysis

**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 1).

TABLE 1 Studies with descriptive analysis

Study	Sample	Result	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 backcourt 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, counterattack efficiency, goalkeeper effectiveness per match, average number of disqualifications and foul per match, and differences in players by position

### 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).

TABLE 2 Empirical studies predominantly with comparative analysis based on 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.

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Study	Sample	Statistical procedure	Variables
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 the 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; Krawczyk, 2015; Lago-Penas, Gomez, Viano, Gonzalez-Garcia, & Fernandez-Villarino, 2013; Oliveira, Gómez, & Sampaio, 2012; Pic, 2018) (Table 3).

TABLE 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 counterattacks
Lago-Penas et al. (2013)	240 matches in the Spanish League during a season 2012/13	Test of Mann-Whitney	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 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 (red/yellow 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 4).

TABLE 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 situationally 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, counterattack 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, the effectiveness of guard networks, positive actions (theft, flight of 6-meters gain, blocked shots) and negative actions (2 minutes of sleep, business volumes)

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 5).

TABLE 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, counterattack, fast attack, percentage of shots and effectiveness.
Prieto et al. (2015a)	60 matches, 280 exclusions, in the 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, centre, 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

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Study	Sample	Statistical procedure	Variables
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

### 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 6).

TABLE 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 1 <sup>o</sup> line; individual action of fast attack and counterattack.
Rogulj et al. (2004)	90 matches Croatian League season 1998-1999.	MANOVA	Number of counterattacks; of prolonged counterattacks; 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 centre.
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.

### 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; Sarmiento et al., 2018; Sarmiento et al., 2014; M. Silva et al., 2016), the common purpose of revised articles in handball is to describe the activity patterns of players and teams.

### **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 this 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.

### **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.

### **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).

### **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.

### *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 (DEA) 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).

#### *Other comparative studies*

In addition to the comparative studies that focused their analysis based on specific variables of players or teams at various competitive levels, there were a number of 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)

#### *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.

Srhom 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 et al. (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.

## 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: (1) in the shots where the main action under study, in relation to which different positions of the players, distances and situations of the game; (2) the differences between winning teams and losing teams; (3) Time Outs and their importance to coaches and teams; and (4) the relation between matches as home team and visitor. Regarding the methods of analysis, articles from the static 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, (1) comparison of winning teams throughout sporting seasons, (2) understanding the effects of major indicators in different match periods, (3) understanding evolutionary tendencies of the match during several times, (4) conducting more studies focused on the defensive profile, (5) analysing international club competitions, (6) analysing video matches and not using other reports provided by the tournament organization, (7) 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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