WOMEN'S BEACH HANDBALL GAME STATISTICS: DIFFERENCES AND PREDICTIVE POWER FOR WINNING AND LOSING TEAMS

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Abstract:

The objectives of the present study were: (i) to compare beach handball game-related statistics by match outcome (winning and losing teams), and (ii) to identify characteristics that discriminate performances in the match. The game-related statistics of the 72 women's matches played at the VIII Women's Beach Handball World Championship (2018) were analysed. The game-related statistics were taken from the official website. A validation of the data showed their reliability to be very good (the inter-observer mean reliability was α=0.82 and the intra-observer mean was α=0.86). For the differences between winning/losing teams a parametric (unpaired *t*-test) or non-parametric (Mann-Whitney U test) test was applied depending on whether the variable met or did not meet normality, respectively. A stepwise discriminant analysis was then performed to determine the variables that predicted performance (victory or defeat). Five variables showed differences between the winning and losing teams: total points (p<.001; ES=1.09), technical faults (p<.001; ES=-0.96), the number of players with either negative (p<.001; ES=-0.86) or positive (p<.001; ES=1.05) valuations and overall valuation (p<.001; ES=1.29). The predictive model correctly classified 80.6% of the matches using two variables (Wilks's λ=0.618; canonical correlation index=0.618): overall valuation and GK shots.

Key words: *performance, goal, goalkeeper, shot, block*

Introduction

Beach handball took an important step towards its consolidation as a sports discipline with its inclusion as an exhibition sport in the Youth Olympic Games 2018, adding to its integration into such international organizations as the European Handball Federation (EHF) and the International Handball Federation (IHF). This institutional guardianship assures the sport's regular international competitions, with the participation of men and women teams from countries on the five continents (Morillo & Hernández-Mendo, 2015). Its consideration as an Olympic sport would mean its definitive consolidation (Pazen, 2016). As a sport that is practised on sand, it not only has a special attraction for professional athletes (Lara, Sánchez, Morillo, & Sánchez, 2018), but also for recreational sportspeople as an activity that offers a wide range of unconventional, fun, and socializing physical activities. This has led its number of practitioners to have grown exponentially in recent years (Lara & Sánchez, 2018). Beach handball is played on a sand pitch (27m × 12m) with three field players plus a goalkeeper on each team. A match consists of two 10-minute sets. The winner of a set is the team that has scored more points by its end. In the case of tied scores, the teams play for a "golden goal". If one team wins both sets, it has won the match. If the teams are tied at one set all, a series of five shoot-outs are played (IHF, 2014). In beach handball, there is permanent numerical superiority in attack, giving it a clear advantage. This numerical superiority comes from the use of the "specialist", a player who takes the place of the goalkeeper during attack (four attacking players

vs three defenders), which leads to predominating offensive play (Skandalis, Hatzimanouil, Papanikolaou, Kanioglou, & Yiannakos, 2017). This coupled with the characteristics of the pitch, the player substitution procedure, and the possibility of taking a goalkeeper-shot after a goal has been conceded generates great dynamism and speed in the game (Lara, et al., 2018). In addition, the existence of two-pointer goals (in-flight shot, spin shot, the goal from a 6-m throw as a penalty for a foul committed by the defending team, and the goalkeeper goal when acting as a field player – specialist player) makes beach handball highly spectacular. These particularities of the scoring system mean that the teams usually end their attacking moves with shots that, if successful, will score double (Lara, et al., 2018). In defence, priority needs to be given to marking the specialist player, to actions that make in-flight shots possible, to specialist player's throws, and to maximizing the difficulty of the spin shot as one of the most commonly used shots (Gruić, Vuleta, Bazzeo, & Ohnjec, 2011). With respect to the physical demands of beach handball, it is a sport with numerous moderate-to-high intensity displacements that are distributed intermittently throughout the game – long periods of low intensity activity interspersed with short bursts of high intensity (Pueo, Jimenez-Olmedo, Penichet-Tomas, Becerra, & Agullo, 2017). It requires highly developed skills involving strength and speed, such as jumping high, and requires complex moves to be made on a sandy pitch (Lara-Cobos, 2011).

Game analyses reveal the tactical and technical options that are most effective and that can discriminate between the winning and losing teams. Since the introduction of what was termed the "Statistic Project" at the 3rd Beach Handball World Championships 2008 in Cádiz, the scouting reports it has generated have been fulfilling an important twofold function: offering coaches relevant information during tournaments and providing valid data and results for the further development of beach handball (Gehrer & Posada, 2010; Köning, Meimaridis, & Gehrer, 2010). The keys to the evolution of the game are being revealed through analyses of game-related statistics, scouting reports, and observational studies. Studies conducted on women's beach handball international competitions point to the most important resource being the preferential use of the spin shot, followed by the specialist shot (Morillo-Baro, Reigal, & Hernández-Mendo, 2015). Nevertheless, the option most used by the best classified teams is the in-flight shot (Lara & Sánchez, 2018). With respect to the finishing zone, the most efficient shooting position appears to be the middle zone. This may be related to the frequent use of the "specialist" in the core of the attack (Skandalis, et al., 2017). Of the tactical options in defence and attack (Gkagkanas, Hatzimanouil, & Skandalis, 2018), women more often use 3:0 in the initial formation of defence, and, in attack, they use both the system with one pivot and the specialist in the middle and that with the pivot and specialist on the left side of the attack in the substitution area. They choose to make the final throwing attempts mainly from the right side and middle zones. The winning teams are found to be favoured over losing teams in the statistics concerning in-flight shots scored, spin shots scored, blocks, and technical faults (Gruić, et al., 2011). Similar results with respect to successful in-flight shots and spin shots were reported in a later study of young women beach handball players (Ohnjec, Kanjugović, & Hećimović, 2017), with goalkeeper effectiveness, successful specialist shots, and direct goals appearing as new variables. This was confirmed in the findings of a later work (Zapardiel, 2018a) which found that one of the aspects deciding the final ranking in the women categories was the effectiveness of spin shots, and that there were differences in the total throw effectiveness percentage in the women's game according to the team's ranking.

In this context, the objectives of the present study were: (i) to compare beach handball game-related statistics by a match outcome (winning and losing teams), and (ii) to identify characteristics that discriminate performances in a match.

Methods

Participants and procedures

Seventy-two matches of the VIII Women's Beach Handball World Championship held in Kazan (Russia) in July 2018 were analysed. All the data were retrieved from the Championship's results books by one of the technicians and checked by one of the study's authors and entered manually into an Excel file. Once the errors had been dealt with, the data were analysed statistically. No informed consent was necessary because the information used was in the public domain on the official website (http://archive.ihf.info/en-us/ihfcompetitions/beachhandball/2018womensbeachhandballwchs.aspx). The analysis of public data taken from websites is habitual in the sports science field. The game-related statistics variables used are listed in Table 1.

The data analysed were validated following the standard procedures of intra- and inter-observer validation used in observational studies (Anguera, 2003; Anguera, Camerino, Castañer, Sánchez-Algarra, & Onwuegbuzie, 2017). First, an *ad hoc* observation instrument was constructed using the LINCE software package (Gabín, Camerino, Anguera & Castañer, 2012). The variables were categorized into four subgroups: goals (spin shots, in-flight, specialist, direct, penalty, and one-pointer), attack/defence (in-flight assists, other

Table 1. Definitions of game-related statistics

Variable	Definition
Total points	The total number of points scored
Spin shots	Converted spin shot percentage relative to the number of shots made
In-flight shots	Converted in-flight shot percentage relative to the number of shots made
Specialist shots	Converted specialist shot percentage relative to the number of shots made
Direct shots	Converted direct shot percentage relative to the number of shots made
Penalty shots	Converted penalty shot percentage relative to the number of shots made
One-pointer shots	Converted one-pointer shot percentage relative to the number of shots made
In-flight assists	The number of passes an attacker makes to a teammate, leading directly to a goal scored with this type of shot
Other assists	The number of other types of assists
Technical faults	The number of turnovers made by the team in attack where the ball was awarded to the defence due to a technical fault in offence such as travelling, illegal dribble and holding the ball for too long
Steals	The number of turnovers in favour of the defence due to actions of anticipation and intercepting and retaining the ball
Blocks	The number of shots blocked by a field player
Suspensions	The number of suspensions while defending
Players with efficiency index = 0	The number of players with a valuation of 0
Players with negative efficiency index	The number of players with a negative valuation
Players with positive efficiency index	The number of players with a positive valuation
Overall valuation (OV)	Score obtained from the following valuation equation: OV= Points – (Spin-shot L/R/LD misses) – (Spin-shot C misses) * 1.25 – (In-flight L/R/LD misses) – (In-flight C misses) * 1.25 – (Spec 6m C misses) * 1.75 – (Spec 6m L/R misses) * 1.5 – (Spec 9m misses) * 1.75 – (Spec DG misses) * 1.5 – (Penalty 6m misses) * 2 – (One-pointer L/R/LD misses) * 1.75 – (One-pointer C misses) * 2 + (In-flight assists) * 2 (Other assists) – (Technical f.) * 2 + Steals * 2 + (Blocked shots) + (Earned susp.) + (Earned 6m) * 2 – (Suspensions) – (Committed 6m) * 2
GB saves	The percentage of shots stopped by the goalkeeper relative to the number of shots made by the attackers
GB spin shots	The percentage of spin shots stopped by the goalkeeper relative to the number of shots made by the attackers
GB in-flight shots	The percentage of in-flight shots stopped by the goalkeeper relative to the number of shots made by the attackers.
GB specialist shots	The percentage of specialist shots stopped by the goalkeeper relative to the number of shots made by the attackers
GB direct shots	The percentage of direct shots stopped by the goalkeeper relative to the number of shots made by the attackers
GB penalty throws	The percentage of penalty throws stopped by the goalkeeper relative to the number of shots made by the attackers
GB one-pointer shot	The percentage of one-pointer shots stopped by the goalkeeper relative to the number of shots made by the attackers
G valuation	Sum of the goalkeeper valuations: GKV= (Spin-shot L/R/LD saves) * 3.5 + (Spin-shot saves C) * 4 + (In-flight L/R/LD saves) * 3.5 + (In-flight saves C) * 4 + (Spec 6m L/R saves) * 4.5 + (Spec 6m C saves) * 5 + (Spec 9m saves) * 2 + (Spec DG saves) * 2 + (One-pointer saves) * 2.5 + (Penalty saves) * 5 – (Conceded goals) * 0.5 + Player OV

Note. GB, goalkeeper blocked; G, goalkeeper; L, left; R, right; LD, long distance; C, centre.

assists, technical faults, steals, blocks, and suspensions), player valuation (players with a positive or a negative index, overall valuation), and goalkeeper (saves, shots, spin shots, in-flight, specialist, direct, penalty, and one-pointer shots, valuation). For the analysis of the goals and goalkeeper subgroups, the effectiveness percentages (goals/shots or saves/shots, respectively) were studied. The final validation was performed using the Cronbach's alpha (α) reliability coefficient statistical test (Cohen, 1988). Two randomly chosen matches were analysed by calculating their intra-observer reliability (at two different time points) and inter-observer reliability (comparison of the observation record with the record downloaded from the official website). The reliability levels considered were (Landis & Koch, 1977): $\alpha<0.10$ no agreement, α from 0.11 to 0.20 poor, α from 0.21 to 0.40 discrete, α from 0.41 to

Table 2. Cronbach's alpha reliability coefficient (α) for intra- and inter-observer reliabilities

Variable group	Intra-observer	Inter-observer
Goals	0.91	0.82
Attack / Defence	0.80	0.72
Player valuation	0.88	0.87
Goalkeeper	0.84	0.79
Mean	0.86	0.82

0.60 moderate, α from 0.61 to 0.80 good; and α from 0.81 to 1.00 very good. In Table 2, one observes that the mean intra-observer reliability was α=0.86, and the inter-observer mean was α=0.82, both of which can be considered as very good.

Statistical analysis

Basic statistical descriptors (mean and standard deviation) by the match outcome (winning and losing teams) were calculated. The normality of each variable was determined using the Kolmogorov-Smirnov test. For the differences between the winning and losing teams a parametric (unpaired *t*-test) or non-parametric (Mann-Whitney U test) test was applied depending on whether or not the variable met normality, respectively. The effect sizes (ES) of the differences were calculated and interpreted following literature recommendations (Cohen, 1988): >0.2 small, >0.5 moderate, >0.8 large. A discriminant analysis was performed using the sample-splitting method according to the match outcome (winning and losing teams) to determine the predictor variables (game-related statistics) of the match outcome (winning or losing team). Wilks' lambda (λ), which measures the deviations within each group with respect to the total deviations, was calculated. Also, the canonical correlation index (deviations of the between-group discriminant scores relative to the total deviations) and the percentage of correctly classified matches (winning and losing teams) were calculated. A p-value of <.05 was considered to be statistically significant. The statistical analysis was performed with the software package SPSS version 24.0 (SPSS Inc., Chicago, IL, USA).

Table 3. Basic descriptors (mean and standard deviation), unpaired-sample t-test (parametric test), Mann-Whitney U test (non-parametric test), p-value, and the effect size of the differences (Cohen's d) for each variable according to the match outcome

	Winners		Losers		*t*	*U*	*p*	ES
	M	SD	M	SD				
Total points (n)	38.14	6.66	29.92	8.38	6.522		<0.001	1.09
Spin shots (%)	63.20	14.94	52.43	15.70	4.214		<0.001	0.70
In-flight shots (%)	70.04	24.81	62.43	31.57		1670.500	0.220	0.27
Specialist shots (%)	69.42	25.99	56.52	26.55		1733.500	0.003	0.49
Direct shots (%)	44.52	43.18	43.09	44.07		468.000	0.904	0.03
Penalty shots (%)	77.52	32.76	83.22	29.71		1590.000	0.298	-0.34
One-pointer shots (%)	82.42	28.22	79.22	26.35		1228.500	0.364	0.12
In-flight assists (n)	3.57	3.41	2.22	1.83		2078.500	0.038	0.49
Other assists (n)	8.40	4.79	5.90	3.41		1829.500	0.002	0.60
Technical faults (n)	5.13	2.14	7.43	2.68		1309.500	<0.001	-0.96
Steals (n)	0.68	1.23	0.60	0.93		2589.000	0.989	0.07
Blocks (n)	1.25	1.43	0.76	1.04		2122.000	0.045	0.39
Suspensions (n)	1.26	1.21	1.47	1.22		2317.000	0.522	-0.17
Players with efficiency index = 0 (n)	2.10	1.21	2.31	1.25		2371.500	0.363	-0.17
Players with – efficiency index (n)	2.10	1.28	3.35	1.62		1449.000	<0.001	-0.86
Players with + efficiency index (n)	5.72	1.26	4.19	1.65		1163.000	<0.001	1.05
Overall valuation (OV) (n)	36.97	14.15	19.69	12.56		797.000	<0.001	1.29
GB saves (%)	30.05	12.13	21.92	9.87	4.417		<0.001	0.74
GB spin shots (%)	32.98	18.15	25.70	13.40		1923.500	0.008	0.46
GB in-flight shots (%)	31.75	31.51	24.41	25.28		1664.000	0.305	0.26
GB specialist shots (%)	32.83	27.06	24.07	24.56		1926.500	0.036	0.34
GB direct shots (%)	57.69	34.01	67.05	35.31		255.500	0.492	-0.27
GB penalty throws (%)	11.79	26.67	13.42	24.69		1563.500	0.426	-0.08
GB one-pointer shot (%)	11.96	22.88	10.91	25.31		1267.500	0.555	0.04
Goalkeeper valuation (n)	19.80	11.42	12.20	11.13		1612.500	<0.001	0.67

Note. OV, overall valuation of the team; GB, goalkeeper blocked.

Table 4. Discriminant analysis by match outcome (winning and losing teams), giving the percentage correctly classified, Wilks' lambda, canonical correlation index, and variables included in the model by the order of selection

Total percentage correctly classified	80.6
Wilks' lambda	0.618
Canonical correlation index	0.618
Variables included (by the order of selection)	Overall valuation; GB saves

Results

Table 3 lists the basic descriptors of the variables by the match outcome (win/lose) for the women's teams. Five variables showed a large ES (Cohen's d>0.80) in differentiating between the winning and losing teams: total points (ES=1.09), technical faults (ES=-0.96), and the number of players with either negative (ES=-0.86) or positive (ES=1.05) valuations, and overall valuation (ES=1.29).

Table 4 presents the results of the discriminant analysis (Wilks' lambda, the canonical correlation index, and the percentage of teams correctly classified) for the match outcome. The predictive models correctly classified 80.6% of the matches using two variables: overall valuation and goalkeeper's saves.

Discussion and conclusions

This study set out to compare the game statistics of the winning and losing teams in the women's category of the last beach handball World Championship, and to develop a multivariate model that predicts the performance of the teams based on those statistics. To the best of the authors' knowledge, this is the first time that the effect size has been calculated to determine the magnitude of the differences in performance and that a multivariate predictive model has been constructed for women's beach handball.

Five variables showed differences between the winning and losing teams: total points (ES=1.09), technical faults (ES=-0.96), and the number of players with a valuation that is either negative (ES=-0.86) or positive (ES=1.05), and overall valuation (ES=1.29) (Table 3). The positive performance indicators were total points and positive valuation. The organization of the game, in which there is almost always numerical superiority in attack, together with the demanding refereeing criterion that penalizes passive play, leads to a great number of throws being made, and therefore of points scored. Previous studies (Gehrer & Posada, 2010; Tezcan, 2013; Zapardiel, 2018a) have noted that the top teams in the final ranking of a championship have greater total points effectiveness. However, the present study found no differences between the winners and losers in the effectiveness of any type of throw. However, it must be noted that the variable "total points" could be influenced by the effectiveness of each type of a shot. The results found are contrary to those of previous studies which found such differences in the effectiveness of spin shot and in-flight throws in both the senior (Gehrer & Posada, 2010; Gruić, et al., 2011) and the U17 and U18 (Zapardiel, 2018a, 2018b) categories. This could reflect the standard equality existing in the World Championship that the present study analysed. Similarly, the number of goalkeeper saves relative to the number of throws received by the goalkeeper was not found to be a variable that differentiated between the winning and losing teams. The same was the case with goalkeeper valuation. In particular, GS showed no significant differences (p=.256) although they did have a very large effect size (ES=0.74). In the same line, the goalkeeper valuation followed the same parameters in terms of p-value and effect size. Although this does not concur with previous studies (Zapardiel, 2018a), these goalkeeper performance criteria could be regarded as secondary, especially as there are moments of a goal left empty when the opponent goalkeeper can throw directly on goal (Lara, et al., 2018). With regard to the negative performance indicators in the present study, there were differences between the winning and losing teams in technical faults and players with a negative efficiency index. These results follow the same line as those of a study conducted for the same championship but in the men's category (Saavedra, Pic, Jiménez, Lozano, & Kristjansdottir, 2019).

The discriminant analysis contrasting winning and losing teams is a type of analysis that has been extensively used in sports sciences (Castellano, Casamichana, & Lago, 2012; Escalante, et al., 2012; Madarame, 2017; Vaz, Mouchet, Carreras & Morente, 2011), and in indoor handball in particular (Rogulj, Srhoj & Srhoj, 2004; Saavedra, Þorgeirsson, Kristjánsdóttir, Chang, & Halldórsson, 2017; Saavedra, Þorgeirsson, Chang, Kristjánsdóttir, & García-Hermoso, 2018; Skarbalius, Pukėnas, & Vidūnaitė, 2013;), since it allows one to determine the predictive capacity of game statistics so as to provide coaches with information that is relevant for them. This method has not, however, been applied to women's beach handball. In the present study, 80.6% of the teams were correctly classified thanks to the overall valuation and GB saves variables (Table 4). The predictive capacity of the overall valuation variable coincides with previous studies of the men's game (Saavedra, et al., 2019). These data seem to suggest that the player valuation index, used by the International

Handball Federation, may be a good indicator of an elite team's performance. Likewise, the GB save variable, analysed as the percentage of shots saved relative to the number of shots made by the attackers, reflects the importance of goalkeeper saves of all kinds of throws for the final result of matches. The goalkeeper is the player whose individual behaviour seems to have most relevance for the final result of the game in beach handball (Gruić, et al., 2011; Zapardiel, 2018a). This suggests the need to pay especial attention to this position when forming a national team or when selecting players for this position.

There are various limitations of this study. First, only the final situations of game actions are analysed (for example, scoring goals or a GB save) without studying what happened before the action, thus leaving out of the analysis relevant data concerning the tactical decision making which took place before and at the moment of the action. Second, the data cover just one championship, which could mean that analysis of a different championship might change the results. Nevertheless, the study has analysed the last major international level championship available. Third, some variables such as "overall valuation", "goalkeeper valuation" and "players' efficiency index" were calculated based on the other variables analysed, which could mean that there was an overlap of use of the data that should be taken into account in interpreting the results.

In conclusion, the total number of points in favour and the number of players in the team with a positive valuation index are criteria that differentiate between the winning and losing teams in women's elite beach handball. Similarly, technical faults and the number of players in the team with a negative index are criteria of poor performance. The variables with the greatest level of discrimination were: overall valuation and GB saves. Coaches could take these results into account to analyse game actions during a match and try to take advantage of them. However, it would be interesting in future research to study what differentiates or predicts the performance of the winning teams in the shoot-out phase after a tie at one set all (1:1).

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