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ANALYSIS OF THE EFFECTIVENESS OF THE OFFENSIVE GAME MODEL IN ELITE HANDBALL

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ABSTRACT

The aim of the study was to identify the success variables associated with the level of efficiency established using an offensive game model during the second phase of the 2013 World Handball Championship for men in Spain. Sixteen matches were selected and 1925 units of observation were analysed, of which 8095 events were recorded using the HandballTAS tool (Handball Tactic Analysis System). The variables analysed to determine offensive effectiveness were individual actions, offensive punishment, degree of opposition, field area, location, numerical situation, and duration. The data were subjected to multivariate analysis in the form of binary logistic regression and classification tree. The classification and regression model correctly classified 81.6% of the dependent variables on offensive effectiveness (assist and numerical situation, p<0.05; field area and location, p<0.001). Offensive effectiveness increases with an assist (53%) and decreases with a shot from the wing-shots (53%), and with a 9-metre shot (65%) compared with a 6-metre shot. In respect of location, efficacy was reduced by 69% with shots in the middle zone of the goal when compared with shots in the lower zone. The probability of success was reduced by 49% in the warning of the passive play situation and 43% in the inferiority situation when compared to the equality situation.

***Keywords**:* Competition efficacy model; Handball; Offensive success; Performance indicators; World Championships.

INTRODUCTION

Complexity in the tactical analysis of team sport is due to the number of elements to be observed such as the enormous variability of behaviours and actions that take place in matches and the various criteria that define them (Franks & McGarry, 1996; Hughes *et al*., 2015). In building a quantitative analysis model, the first step is to define performance indicators and their link to outcomes (Hughes & Bartlett, 2002; Franks & Hughes, 2004). The identification of these tactical parameters, which define handball effectiveness, allow corrections to be made to technical-tactical errors in the training process (Trninić *et al*., 2011). Handball represents a sport of ending, where the outcome depends on performance in each of the possessions to produce quantifiable success or failure (Sampaio & Janeira, 2003). The goal is the only element that is assigned a numerical value: it defines the participation of both teams, and it is directly reflected in the outcome (Rogulj, 2000; Gruič *et al*., 2006). The objective of both teams is the same, to score more goals than the opponent or to achieve a s favourable a result as possible by the application of handball technical-tactical elements at the disposal of the players on the court (Ohnjec *et al*., 2008). There is a relationship between the number of possessions and the probability of scoring a goal. During a match, it is possible to record the success of a player based on the effectiveness of goal shots, number of goals scored from different playing positions, turnovers, technical mistakes and more (Milanović *et al*., 2018).

The offensive performance of elite handball teams has a greater influence on the success of the game (Vuleta *et al*., 2012). Analysis of the indicators associated with finishing actions and the scoring of goals supports an effective model of play. There is an avenue of research that starts from general and specific analyses of various aspects of the game (especially offensive). Determining the performance factors of the team and the resulting influence of such factors on the outcome of the game is an essential aspect of choosing an efficient game model (Ferrari *et al*., 2019).

Several studies have shown various performance indicators that influence the outcome of a game (Foretić *et al*., 2010; Gómez *et al*., 2014; Karastergios *et al*., 2017; Saavedra *et al*., 2018). Other studies analysed the effectiveness of factors such as "shooting" (Srhoj *et al*., 2001; Ohnjec *et al*., 2008); type of throwing (Vuleta *et al*., 2003; Saavedra *et al*., 2019); the areas of throwing (Ohnjec *et al*., 2008; Meletakos *et al*., 2011; Almeida *et al*., 2020); the number of attacks (Sevim & Bilge, 2007; Volossovitch *et al*., 2010; Bilge, 2012); the numerical situation (Skarbalius *et al*., 2004; Prudente *et al*., 2019); the level of performance (Belcic & Sporis, 2012); and the collective tactical elements (Rogulj *et al*., 2004; Prudente *et al*., 2017). Nevertheless, these studies did not analyse the interaction between individual, situational, numerical or temporal variables depending on the outcome of each observation unit. The performance and success of a handball team depends on a variety of factors, and models of efficiency are different in every team and almost every match (Skarbalius *et al*., 2013). It is known that winning teams have higher throwing efficiency percentages, but how should those throws be executed? From where should they be executed? In what numerical situation are they most probably executed? What timing for throws is appropriate to achieve the highest efficiency? Do deep attacks have a more successful outcome?

Taking this into account, the study objective was to determine an offensive game model by establishing which variables influence each of the attacks, to determine the success rate. This study aimed to (1) identify the game variables that affect success at the end of attacks and (2) analyse the offensive behaviour associated with offensive efficiency.

METHOD

Sample

The observation units were collected from 16 matches of the XXIII Men's World Handba l Championship held in 2013. Matches for the second phase were selected to ensure a homogeneous performance level and greater competitive parity. The matches analysed were obtained from the official website of the Spanish national television: www.rtve.es. A total of 1925 units of observation were analysed, in which 8095 events were recorded.

Data source and reliability

Data were obtained from the HandballTAS tool (Handball Tactic Analysis System) which has been validated in a previous study (González-García *et al*., 2016). The reliability values of the individual actions were calculated following the method developed by Hopkins (2006). The HandballTAS tool was analysed and we obtained good inter-observer reliability (the intra -class correlation coefficients varied from 0.77 to 1.00, showing a good level of reliability, and standardised typical errors were located in a range from 0 to 0.55) of the actions of the players involved in the match as registered by the independent observers. The high Kappa values, intra-class correlation coefficients, and the low standardised typical errors showed a high level of inter-observer reliability using the HandballTAS tool. Multivariate analyses were used to determine the offensive efficiency.

Ethical considerations

This study conformed to the standard set by the Declaration of Helsinki and was approved by the University of Vigo ethics committee with the code number 4-1292-15.

Variables

Based on the studies that analysed the different phases of the game, we ultimately selected 25 variables related to the offensive phase and grouped them into individual, spatial, numerical and temporal variables (see Table 1).

Statistical analysis

For the first outlined aim of this study, a binary logistic regression analysis was carried out in which the dependent variable used was the offensive success. For the second aim, both classification and hierarchical segmentation analysis were carried out using a multivariate analysis technique. The analysis was performed using IBM SPSS Statistics Application for Windows, Version 22.0 (Armonk, NY: IBM Corp.). According to the analysis, statistical significance was $p<0.001$ or $p<0.05$.

In the binary logistic regression analysis, all the independent variables were considered except turnover and offensive foul, to maintain a degree of dependence with the dependent variable. Distractions of the rest of the independent variables and the variable "free-throw" were considered to be non-significant.

In the multivariate analysis, we applied the decision-tree technique; the exhaustive CHAID algorithm was used to explain the offensive efficacy, using influence or explanatory variables. Cross-validation was used in the model. Each variable in the model of offensive efficiency (OE) was defined as a factor depending on the explanatory importance in the model. α, β and γ were the coefficients of each independent variable. The model is as follows:

$$OE = \alpha \text{ (Factor 1)} + \beta \text{ (Factor 2)} + \gamma \text{ (Factor 3)} + \ldots + \kappa \text{ (Factor } \kappa)$$

Table 1. **SELECTED STUDY VARIABLES**

Groups	**Operational definitions of variables**
Offensive efficiency	Level of success of the attack, depending on whether a goal is scored or not.
Individual action	*Assist:* Technical action of an attacking player with a ball, which, through a pass, makes it possible to shoot without opposition. *Free-throw:* The attacking player is the subject of an infraction by a defending player. *Offensive foul:* An attacking player performs an infraction on the defending player, thus, the defending player loses possession. *Turnover:* The attacking player loses the ball by any circumstance of the game or violation of the rules of the game (offensive foul, steps, illegal dribble, entering the goal area, foot fault or passive play).
Offensive punishment	*Yellow card:* Warning reflected by the referee as a result of foul or unsportsmanlike conduct. *Exclusion:* A suspension (2 minutes) reflected by the referee caused by repeated fouls, unsportsmanlike conduct, an incorrect change or as a result of a disqualification. *Disqualification:* Disciplinary sanction implemented by the referee resulting in a red card, applied for unsportsmanlike conduct after receiving a 2-minute suspension or for aggression. *Passive play:* Sanction indicated by the referee on the player to whom the attacking team loses possession due to a previous warning of passive play.
Degree of opposition	According to the number of defenders in front of a shot. *Without opposition:* Shooting action is carried out by a player in a regulatory form to the goal without any defender between the imaginary line that connects the ball and the goalkeeper. *With opposition:* Shooting action is carried out by a player in a regulatory form to the goal with at least one defender in the line of shooting.
Field area	The area where the shooting takes place. It is distinguished between a zone of 6 metres, a central area close to the goal area; a zone of wing-shots, which are side areas near the goal area; a zone of 9 metres, the furthest zone of the area; and a 7-metre zone, which is a zone from where shoots of 7 metres are produced after the referee indicates a 7-metre penalty.
Location	According to the area of the goal in which the shot is located depending on the height, there is a distinction between the low zone, middle zone and high zone. The shots that are not directed towards the goal are classified as outside.
Numerical situation	Depending on whether the number of players in the attacking team are in numerical equality, inferiority or superiority, it is classified as a warning of passive play, regardless of the number of players, when the attacking team does not intend to throw a goal and the referee raises his right arm indicating the forewarning signal for passive play.
Duration	Depending on the time elapsed in each attack, it is classified as a fast attack, with timing of less than or equal to 10 seconds; short attack, greater than 10 seconds and less than or equal to 25 seconds; half attack, greater than 25 seconds and less than or equal to 50 seconds; and long attack, greater than 50 seconds.

RESULTS

The results reported a total of 1925 units of observation, of which 849 (44.1%) achieved success (goal) and 1076 (55.9%) did not succeed (not a goal). The rest of the independent variables were analysed, and we observed a statistically significant relationship ($p<0.001$; $p<0.05$) between the variables of OE (see Table 2).

Table 2. **DIFFERENCES IN THE VARIABLES REGISTERED WITH THE TOOL DEPENDING ON THE OFFENSIVE EFFICIENCY**

Variable	Success		Not success		χ^2
	n	%	n	%	
Assist	357	67.7	170	32.3	164.475**
Offensive foul	0	0	98	100	81.473**
Turnover	0	0	294	100	273.791**
Offensive punishment					15.471*
Yellow card	46	54.1	39	45.9	
Exclusion	62	56.9	47	43.1	
Disqualification	4	66.7	2	33.3	
Passive play	0	0	3	100	
Degree of opposition					570.379**
Without opposition	511	68.7	233	31.3	
With opposition	334	49.1	346	50.9	
Field area					615.742**
6 metres	384	74.3	133	25.7	
Wing-shots	136	56.0	107	44.0	
9 metres	242	43.8	310	56.2	
7 metres	80	73.4	29	26.6	
Location					891.652**
Low	434	76.8	131	23.2	
Middle	207	51.8	193	48.3	
High	206	74.6	70	25.4	
Numerical situation					27.873**
Equality	634	45.2	769	54.8	
Warning of passive play	32	29.9	75	70.1	
Inferiority	63	32.8	129	67.2	
Superiority	120	53.8	103	46.2	
Duration					21.481**
Fast	177	55.3	143	44.7	
Short	263	43.7	339	56.3	
Half	300	40.1	449	59.9	
Long	109	42.9	145	57.1	

**p<0.001; *p<0.05.

The final proposed model was composed of the constant and effect of four variables (assist, field area, location and numerical situation), as can be seen in Table 3. For the individual actions, the model only took “assist” into account ($p<0.05$) so that the probability of success increased by 53% when the variable was given. For the variable “area of the field”, the probability of success decreased by 53% with a shot from the wing-shot zone ($p<0.001$) against a shot from the 6-metre zone. When the shot occurred from the 9-metre zone ($p<0.001$), the probability of success decreased by up to 65% compared with a shot from the 6-metre zone. For the shots from the 7-metre zone, no statistically significant result was observed, and the probability of success neither increased nor decreased with the reference category .

Table 3. **LOGISTIC REGRESSION MODEL FOR THE OUTCOME IN THE OFFENSIVE PHASE (N=1925)**

Variable		**B**	**Error**	**Wald**	**Exp(B)**	**p**
Constant		1.693	0.170	98.810	5.435	.000**
Assist		0.428	0.179	5.737	1.534	.017*
Field area	6 metres			47.090		.000**
	Wing-shots	–0.756	0.203	13.798	0.470	.000**
	9 metres	–1.039	0.173	36.111	0.354	.000**
	7 metres	0.028	0.287	0.009	1.028	.923
Location	Low			113.748		.000**
	Middle	–1.156	0.148	60.827	0.315	.000**
	High	–0.213	0.179	1.424	0.808	.233
Numerical situation	Equality			14.268		.003*
	Warning of passive play	–0.663	0.287	5.326	0.515	.021*
	Inferiority	–0.556	0.215	6.685	0.574	.010*
	Superiority	0.263	0.208	1.610	1.301	.204

**p<0.001; *p<0.05.

For the location variable ($p<0.001$), shooting in the middle of the goal decreased the probability of success by 69%, compared with a shot aimed at the low zone. Although shooting into the high zone did not differ significantly, the probability of success was reduced by 20% compared with shooting into the low zone.

Regarding the warning of the passive play situation and the inferiority situation, the probability of success was reduced by 49% and 43%, respectively, compared with the equality situation ($p<0.05$). Although the superiority situation did not indicate significant differences, attacking in superiority increased the probability of success 1.3 times compared with attack in numerical equality.

The proposed regression model was considered to provide a good fit for the data (Lago *et al*., 2012). At the time of evaluating the model, the cut-off point for the classification was established as 0.5. The model correctly classified 81.6%, indicating a correct percentage of 75.5% for unsuccessful attacks and 89.3% for successful attacks (see Table 4). The result of the Hosmer-Lemeshow test was: $\chi^2(4, N=1925)=11{,}705$; $p=0.111$. The model established an R^2 of 0.634, indicating that 63% of the offensive effectiveness was explained by the variables included in the model.

Table 4. **CLASSIFICATION OF THE REGRESSION MODEL PROPOSED FOR THE ATTACK PHASE**

Observed	**Prediction**		
	Not success	**Success**	**% correct**
Not success	812	264	75.5
Success	91	758	89.3
% global			81.6

A graphical representation of the tree model was plotted, to analyse the offensive behaviour associated with offensive effectiveness (Figure 1). Each node contains a frequency table indicating the number of cases (frequency and percentage) considering whether there was success or not in each attack. The estimated risk was 0.184 and the standard error of classification was 0.009. The predicted category with the highest frequency value on each node is highlighted with a grey stripe. The variable location ($p<0.001$; $\chi^2=891.296$) represents the first variable of the model. Node 2 indicates that, out of the 43.7% of shots that were heading to the low zone and high zone, 76.1% ended in a goal. Following the branching of the diagram, the second variable is the field area ($p<0.001$; $\chi^2=61.883$). Node 6 indicated that out of the attacks that ended in wing-shots, those in the 7-metre or 6-metre zone obtained a more considerable number of goals with 84.4%, compared with the attacks that ended in the 9-metre zone, with 60.1%.

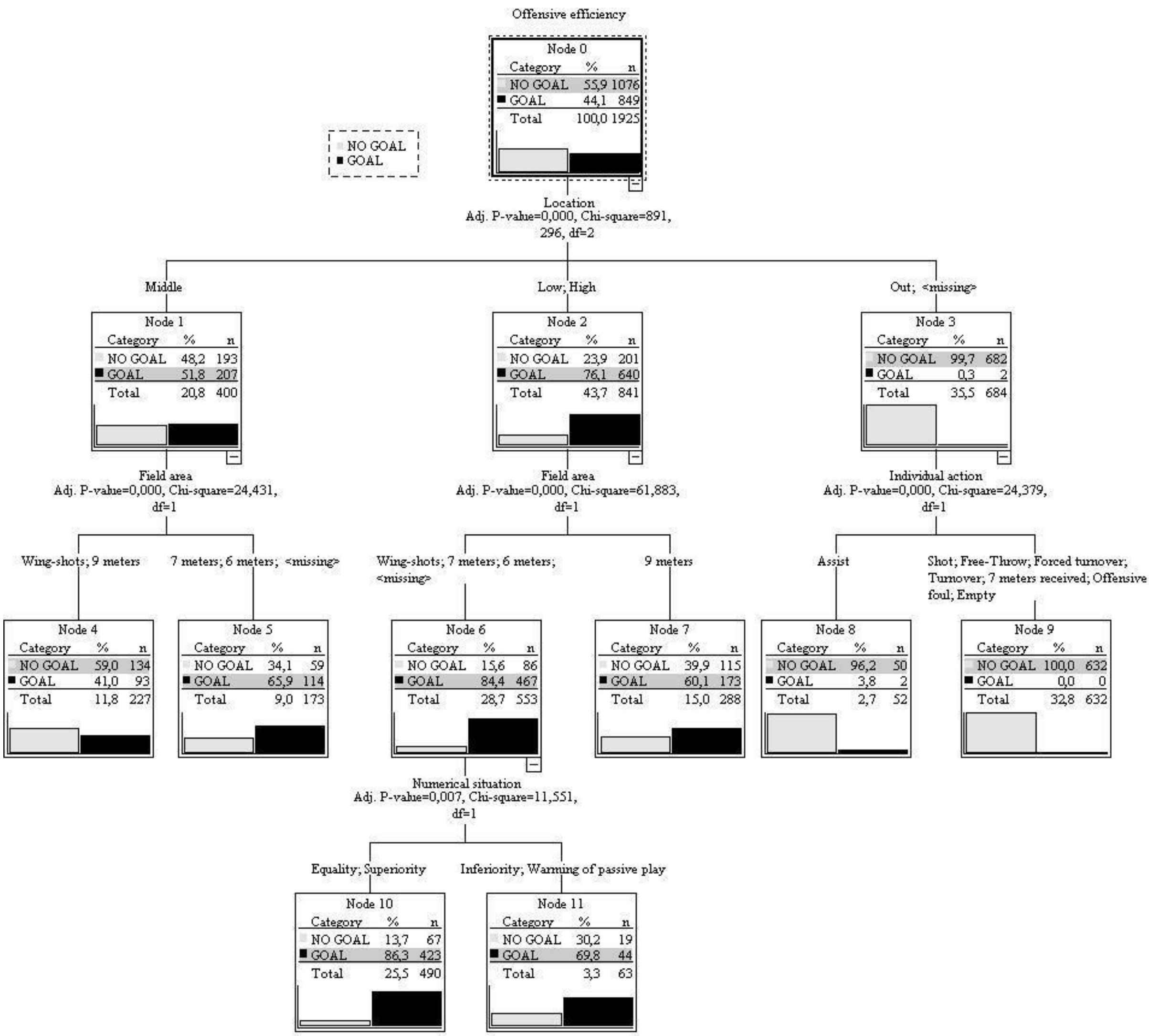

Figure 1. **TREE DIAGRAM FOR THE EXHAUSTIVE CHAID METHOD OF OFFENSIVE EFFECTIVENESS**

The third variable was numerical situation ($p<0.05$; $\chi^2= 11.551$). Node 10 indicates that 86.3% of a total of 25.5% of attacks in numerical equality and superiority ended with a goal, compared with 69.8% of a total of 3.3% of attacks in inferiority and warning of passive play.

The summary of the terminal nodes of the model is offered in the gains for nodes, i.e., those in which the growth of the tree stops and those that represent the best classification predictions for the model. Node 10 was the one that offered a better model analysis with 490 cases and with a percentage of 25.5% of the total node. It should be considered that this node explains the offensive effectiveness of the attacks in which there is the most significant probability of success: in a situation of equality or superiority, with a shot made from the wing-shots or a 6-metre zone and located in the low zone or high zone. Node 10 explains 423 attacks that ended in a goal where 49.8% of the total attacks ended in a goal. The value of response indicated that 86.3% of the cases of node 10 ended in a goal (Table 5).

Table 5. **RESPONSE VALUE OF OFFENSIVE SUCCESS ATTACKS WITH THE EXHAUSTIVE CHAID METHOD**

Node	Node		Gain		Response	Index (%)
	n	%	n	%		
10	490	25.5	423	49.8	86.3	195.7
11	63	3.3	44	5.2	69.8	158.4
5	173	9.0	114	13.4	65.9	149.4
7	288	15.0	173	20.4	60.1	136.2
4	227	11.8	93	11.0	41.0	92.9
8	52	2.7	2	0.2	3.8	8.7
9	632	32.8	0	0.0	0.0	0.0

Figures 2 and 3 shows visually the areas occupied by each of the variables analysed. Figure 2 is divided into two squares. The square on the left represents the different situations in which it is observed that the attack does not end in goal. For example, it can be observed graphically that the percentage of attacks that do not end successfully occurs before a situation of numerical equality without shot. The square on the right shows the attacks that end in goal. It is observed that the highest percentage are represented in attacks in a situation of numerical equality, with a shot directed to the lower area of the goal and from the 6 -metre zone. Figure 3 shows visually the different situations observed in attacks that end in goal. The left square represents attacks in numerical equality and the left square represents attacks in numerical inferiority, numerical superiority and warning of passive play. The highest percentage of attacks in numerical equa lity correspond to shots directed to the lower area of the goal, including shots from the 6 -metre zone, 9-metre zone and 7-metre zone.

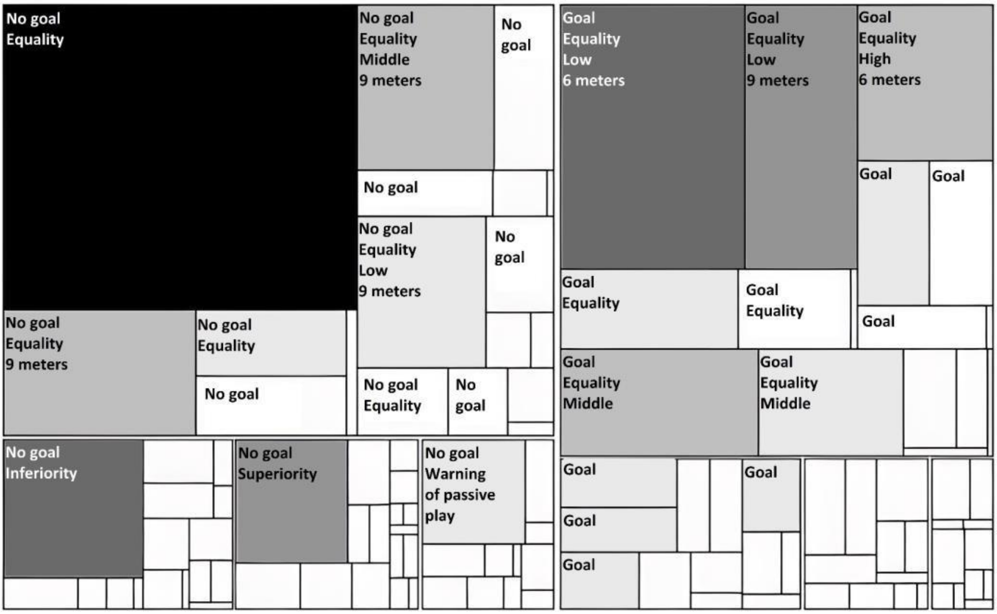

Figure 2. **DISTRIBUTION OF ATTACKS NOT ENDING IN A GOAL AND ATTACKS ENDING IN A GOAL.**

Figure 3. **DISTRIBUTION OF ATTACKS ENDING IN A GOAL ACCORDING TO THEIR NUMERICAL SITUATION**

DISCUSSION AND CONCLUSIONS

In this study, variables that have the most significant influence on offensive effectiveness were grouped. Despite the numerous studies on the influence of performance variables on game effectiveness (Gruič *et al*., 2006; Ohnjec *et al*., 2008; Foretić *et al*., 2010; Meletakos *et al*., 2011; Gómez *et al*., 2014; Milanović *et al*., 2018; Almeida *et al*., 2020), the classification models have not been used to explain the performance of teams in handball.

For the first aim, binary logistic regression analysis was used to indicate the probability of scoring a goal in the attacks in relation to the offensive game variables. According to the results of the offensive model, the probability of scoring a goal in an attack is increased by an assist ; decreased by a throw from the 9-metre zone or the wing-shots compared with a throw from the 6-metre zone; decreased by a throw from the middle of the goal compared with a throw from the low zone; and decreased in a situa tion of warning of passive play or a situation of inferiority. Other studies have analysed types of variables such as situational variables (Lago-Peñas *et al*., 2013); missed shots and goals (Vuleta *et al*., 2012); effectiveness by specific positions (Srhoj *et al*., 2001); and technical errors (Gruič *et al*., 2006). For example, Gruič *et al*. (2006) showed that an assist is an element that predicts offensive success. This is similar to our finding that assist increases the probability of scoring a goal. Success in throws influences the outcome of the match. Consistent with our results, Srhoj *et al*. (2001) concluded that the greatest effectiveness of the shot occurred at short distances and without opposition, and the least effective shot was from long distances and opposed by defenders. However, these studies did not take into account variables analysed in our study such as warning of passive play or the location of the shot, which have been shown to have an influence on the final outcome of the attack. It should be noted that the situation of warning of passive play has not been analysed by other studies in relation to offensive effectiveness.

Volossovitch and Gonçalves (2003) proposed a "formula" for winning based on three variables that significantly affect the outcome of the game: the effectiveness of the goalkeeper, the effectiveness of the shot and the effectiveness of the counter-attack. In the present study, of these three variables, the effectiveness of the throw was analysed, taking into account both the throw zones and the goal zones where the shot was located. This last variable is related to the effectiveness of the goalkeeper and determines the areas in which the goalkeeper has a lower percentage of efficiency. This is because the highest percentage of effectiveness in attack occurs in shots directed to the lower areas of the goal.

Lago-Peñas *et al*. (2013), using a linear regression model, analysed the effect of situational variables on the outcome of the matches of Asobal League teams. The main difference between their study and ours was that the authors included situational variables in the model, i.e., the location of the match and the quality of the team, and game variables, i.e., the turnovers or the total throws, which were not included in our study. The model of Lago-Peñas showed an adjusted R^2 of 0.76, stating that 76% of the probability of winning was the result of the variables included in the model. In contrast, an adjusted R^2 of 0.63 was established in our research, showing that 63% of the variation in offensive effectiveness was explained by the game variables included in the offensive model. The remaining 37% of variability could be explained by the remaining offensive game variables that the model did not consider when explaining the probability of scoring during the attack. These variables could be included in future research.

Vuleta *et al.* (2012) established a model in which missed shots and counter-attack goals were the ones that most affected the difference in the goal scored. Using regression analysis, they calculated a correlation coefficient of 0.92, which indicated a high correlation. They took both missed shots and successful shots from different areas of the field as predictive variables. According to the results, a missed shot severely affected the goal difference by 0.46 and a counter-attacking goal positively affected it by 0.50. The variability of the prediction system and the model variables used explained 85% (adjusted R^2=0.77); the remaining 23% of the variability in the outcome could be explained by technical or tactical actions, goalkeeper effectiveness or other undefined factors. These values differ from the results of the present research, which had an adjusted R^2 of 0.63. However, our model ranked correctly 81.6%, revealing a correct percentage of 75.5% for unsuccessful attacks and 89.3% for successful attacks.

Similar results were obtained by Srhoj *et al.* (2001) in their proposed model, confirming that shots from central positions close to the goal between the defenders or in a counter-attackwere those that contributed more to the effectiveness of the attack, reinforcing the theory that centrality and depth in shots reaches the highest possible effectiveness. It should be mentioned that these results are similar to ours because the proposed model shows that shots from the 6 -metre zone have a greater probability of finishing in goal. The results of their regression analysis showed that the predictor variables explained 0.76 of the model, a higher percentage than the 63% predicted by our model. Lower effectiveness was produced with long-distance shots opposed by defenders or from wing-shots with little angle, which is in line with the results of this research. The frequency and the effectiveness of shots from certain positions served as predictive variables in the outcome.

To account for the second aim, a game pattern was modelled suggesting a classification and hierarchical segmentation analysis in which the game variables influencing offensive effectiveness were explained. Such analysis is recognised as the decision-tree technique, and its use is novel in this type of study. The model of the game analysed included the following variables ($p<0.01$): location of the shot, the zone of the field and the numerical situation. The first variable influencing the offensive effectiveness represented the location of the shot ($p<0.001$; χ^2= 61,883). The most effective shots were directed at high and low areas of the goal (76.1%). Studies that analysed the goalkeeper's effectiveness showed a direct correlation in the winning teams (Skarbalius *et al.*, 2013). As Hansen *et al.* (2017) indicate, save percentage is strongly related to competitive success in short-term competitions, such as a world championship. However, the location of the shot has been rarely studied as another variable that affects offensive effectiveness. The second variable was the area of the field ($p<0.001$; χ^2= 61,883). The attacks that ended in the wing-shots, the 6-metre zone or the 7-metre zone were more effective (84.4%). Efficiency decreased in attacks that ended in the 9 -metre zone (60.1%). Thus, manifest variables such as the efficiency of shots from the wing-shots and the pivot are factors to be taken into account to promote second-line inside play. Winning teams have high-efficiency values in these shots (Foretić *et al.*, 2010). Finally, the third variable was numerical situation ($p<0.01$; χ^2=11,551). The attacks with the highest probability of success were in a situation of numerical equality or superiority with 86.3% effectiveness. When attacks occurred in an inferior situation or a situation of warning of passive game, the success rate decreased to 69.8%. These situations should be avoided to preserve a high probability of scoring a goal. The practical value of this research is characterised by the idea that there is an importance in taking advantage of situations of numerical superiority by increasing offensive effectiveness (Skarbalius *et al.,* 2004).

In the offensive performance model proposed by Alexandru *et al.* (2009), the highest offensive effectiveness was obtained in counter-attacking shots, at 88.23%, penetration shots, at 75%, and 7-metre shots, at 73.71%. They noted additionally that throwing effectiveness was directly proportional to ranking in the championship. Foretić *et al.* (2013) defined a model of evaluating effectiveness through a set of 48 game variables related to the offensive, defensive and goalkeeper effectiveness phases. According to the model, the total effectiveness of the players was expressed as the relative value of the sum of the attack and defence scores, about the coefficient of each phase of the game. Dumangane *et al.* (2009) and Volossovitch *et al.* (2010) analysed the previous performance of the team, the current level, the balance in the outcome and the number of possessions per match of each team. The results suggested the probability of scoring a goal did not depend on the previous offensive performance of the team itself, but it did affect the previous performance of the opponent and the difference in the result of each possession in the matches with teams of different level, ranking and rhythm of the alternation of the possession. This should include not only a prior analysis of the team's events but also information on the opponent's performance.

It should be noted that none of the proposed studies analysed the variable of location of throw in offensive effectiveness and likewise do not take into account the match situation, either in terms of the number of players or in situations of warning of passive play. The incorporation of these experimental variables in future studies may be beneficial to a more in-depth analysis of the performance indicators that affect each of the game units and the outcome.

The most reasonable probability of scoring a goal is obtained with an assist before a shot from the 6-metre zone, directed at the lower part of the goal and in a situation of numerical superiority. The offensive model that best predicts offensive effectiveness is to locate the throw to the low zone or the high zone of the goal and make the throw from the 6-metre zone, in a situation of numerical equality or superiority and with a duration less than or equal to 10 seconds. The probability of scoring a goal increases significantly when an assist is achieved. The probability decreases significantly with a shot from wing-shots or the 9-metre zone, with a shot located in the middle of the goal and with an attack in a situation of warning of passive play or numerical inferiority.

PRACTICAL APPLICATIONS

The proposed game model cannot be generalised to teams and must be subject to the specific characteristics of their players. It is an idiosyncratic game model adjusted to the particularities of the Spanish National Team. The possible construction of an effective model of efficient attacking play in handball is a priority of the successful coach. Depending on the peculiarities of the equipment, other game models with different variables could be proposed.

The national team's offensive play was initially based on achieving rapid transitions in numerical superiority. The importance of performing fast attacks is fundamental to the increase in success rate. It is not only the counterattacks made by a team that determines their success.

Results showed that a positional game model based on continuity, commonly called "one more-pass", finishing with no opposition, increases offensive effectiveness. A collaborative associative game should be encouraged, and 1 × 1 situations should be avoided.

The offensive model proposes a finishing close to the 6 -metre zone. In the deep game, looking for penetration situations causes reckless actions, either attracting the help of the defenders or producing 7-metre situations. A game based on combined actions between front-line players and pivots will manage to cause a defensive error. Reduced 2 × 2 game situations or the search for 3 × 2 numerical superiority using second-line players will increase the efficiency of the attack. It would be useful to practise the situation of numerical superiority, as the offensive effectiveness in this situation increases during the match. After throws from the central zone in 6 metres, the most significant percentage of effectiveness is found in throws from wing-shots. Considering the possibility of finding closed defences while avoiding the game in the central zone, the alternative is to expect a game played more widely, with greater amplitude of players and with finishing from wing-shots.

The effectiveness of the proposed model was confirmed (Spanish team) in the World Championship in 2013. Based on this successful model, although with different players, the Spanish team has achieved the following in the European Handball Championships over the years: bronze in 2014, sub-champion in 2016, and champion in 2018 and 2020. Subsequent research could verify the evolution of this model and its performance in the game.

Conflict of interest
The authors report no conflict of interest.

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