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Sequential analysis of the interaction between kicker and goalkeeper in penalty kicks

Análisis secuencial de la interacción entre lanzador y portero en penaltis

Análise sequencial da interação entre o jogador e o guarda-redes nos pontapés de penálti

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ABSTRACT

Within the observational methodology, an analysis of the interaction between kickers and goalkeepers has been carried out, in penalty kicks taken in international team competitions, which allows the goalkeeper to obtain relevant information about the area of the goal to which the kick is going to be directed from the information perceived at different moments of the kick. Data recording and coding was carried out using LINCE software. The record, based on the observation instrument, is structured around four critical frames and possible conditional frames. The reliability of the records was guaranteed by intra-observer and inter-observer agreement, using Cohen's Kappa coefficient. A lag sequential analysis has been carried out, which has been facilitated by the diachronic structure of the record. Based on the results of this analysis, it concluded with a series of relevant guidelines that can be used by goalkeeping coaches to help their goalkeepers to face a penalty kick, considering the information of the context of the penalty kick, of the moment in which the kicker starts his approach to the ball, the interaction between the kicker and the goalkeeper, the moment in which the non-dominant leg of the kicker makes his last support before the kick, and the moment in which the kicker hits the ball.

Keywords: football; penalty; goalkeeper; observational methodology; lag sequential analysis; international team competitions.

RESUMEN

En el seno de la metodología observacional se ha realizado un análisis de la interacción entre lanzadores y porteros, en penaltis ejecutados en competiciones internacionales de selecciones, que permita al portero obtener información relevante sobre la zona de la portería a la que va a ir dirigido el lanzamiento a partir de la información extraída en diferentes momentos del lanzamiento. El registro y codificación de los datos se ha realizado mediante el software LINCE. El registro, a partir del instrumento de observación, se vertebra por cuatro *critical frames* y de posibles *conditional frames*. Se ha garantizado la fiabilidad de los registros mediante concordancia intra-observador e inter-observadores, utilizando el coeficiente Kappa de Cohen. Se ha realizado un análisis secuencial de retardos que se

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ha visto facilitado por la estructura diacrónica del registro. Fruto de los resultados de este análisis se concluye con una serie de pautas relevantes que puedan servir a entrenadores de porteros para ayudar a sus porteros a afrontar un lanzamiento de penalti, considerando la información del contexto del penalti, del momento en el que el lanzador comienza su aproximación al balón, de la interacción mantenida entre lanzador y portero, del momento en que la pierna no dominante del lanzador hace su último apoyo antes del golpeo, y del momento en que el lanzador golpea el balón.

Palabras clave: fútbol; penalti; portero; metodología observacional; análisis secuencial de retardos; competiciones internacionales de selecciones.

RESUMO

No âmbito da metodologia observacional, foi realizada uma análise da interação entre os cobradores e os guarda-redes, em penalidades cobradas em competições internacionais de seleções nacionais, o que permite ao guarda-redes obter informações relevantes sobre a zona da meta para a qual o pontapé vai ser dirigido a partir das informações extraídas em diferentes momentos do tiro. O registo e a codificação dos dados foram efectuados com recurso ao software LINCE. O registo, a partir do instrumento de observação, baseia-se em quatro quadros críticos e possíveis quadros condicionais. A fiabilidade dos registos foi garantida através da concordância intra-observador e inter-observador, utilizando o coeficiente Kappa de Cohen. Foi realizada uma análise sequencial, facilitada pela estrutura diacrónica do registo. Como resultado dos resultados desta análise, concluímos com uma série de orientações relevantes que podem ser utilizadas pelos treinadores de guarda-redes para ajudar os seus guarda-redes a enfrentar um penalti, considerando a informação do contexto do penalti, o momento em que o rematador inicia a sua aproximação à bola, a interação entre o rematador e o guarda-redes, o momento em que a perna não dominante do rematador faz o seu último apoio antes do remate, e o momento em que o rematador bate a bola.

Palavras chave: futebol; penalti; guarda-redes; metodologia observacional; análise sequencial; competições internacionais de seleções.

INTRODUCTION

In the penalty kick, there is a diachronic interaction between the kicker and the goalkeeper; one with the aim of scoring and the other with the aim of avoiding a goal, and the behaviour of one influences the behaviour of the other (Pereira & Patching, 2021).

The pressure experienced by the player when taking the shot also conditions the final outcome (Ellis & Ward, 2022; Furley et al., 2017; Jordet, 2009), with the likelihood of the kicker missing the shot increasing the more they are in play (Arrondel et al., 2018). Nevertheless, it is a unique opportunity for the kicker to score -73.2% of penalties shot in World Cups and European Championships end in a goal (Noël et al., 2021)-. The goalkeeper success rate in World Cups is around 20% (Morya et al., 2005); this rate could increase if the goalkeeper exerted more pressure on the player by making distracting manoeuvres (Wood et al., 2015). Van der Kamp and Masters (2008) concluded that if the goalkeeper waves his arms, tighter and lower shots tend to be produced.

Noël et al. (2021) found that 72.66% of shots are made with a strategy independent of the goalkeeper -the player has previously set his shot without considering the possible actions of the goalkeeper during the run-. Shooting with this strategy gives the goalkeeper the opportunity to obtain information prior to the shot in order to guess where the ball is going to go. From the time the player hits the ball until it reaches the goal it takes approximately 500 ms (Franks & Harvey, 1997); the goalkeeper needs around 600 ms to reach the ball shot to either side or even 1000 ms if it is aimed at an upper corner (Dicks et al., 2010 a) so the anticipation of the destination of the penalty kick is relevant to the goalkeeper's success (Dicks, Davis et al., 2010).

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The player's start of the run may indicate where the shot will be directed; players who start the run at a greater angle of approach to the ball tend to throw to the side of their dominant leg (Williams & Griffiths, 2002). As far as the approach run is concerned, and according to Noël et al. (2015), if the player advances quickly towards the ball, without looking at the goalkeeper, they are likely to end up shooting to their natural side -in the right-handed player the right side of the goalkeeper (Palacios-Huerta, 2003)-; and, if the approach is slow and the player keeps their gaze on the goalkeeper, they are probably opting for a goalkeeper-dependent strategy, in which case the goalkeeper is recommended to wait for his final move. Kuhn (1988) found a higher success rate for goalkeepers who waited to dive later -close to the time the player hit the ball- with skilled goalkeepers being the ones who wait the longest to dive in order to extract more information from the thrower (Furley et al., 2017). Goalkeepers usually start their movement 50 ms before the player hits the ball (Dicks et al., 2010 b). Taking into account that the time between the support of the non-dominant leg and the shot to the ball is 0.10 seconds (Inoue et al., 2014) makes that a good moment to make a decision and execute the movement is just when the kicker supports the non-dominant leg -up to 85% of the shoots are directed to the place where the supporting foot is pointing (Nadal et al., 2018).

The position of the player's body at the moment of striking the ball helps to predict where the ball will go. The orientation of the kicking foot is around 80% related to the final direction of the shot (Franks & Harvey, 1997), although goalkeepers often do not consciously pay attention to this factor (Diaz et al., 2012).

Once the player hits the ball the goalkeeper will usually need more time to reach the ball (Van der Kamp et al., 2018) and only in a shot that is not tight can they reach the ball. If the goalkeeper has reached this point without launching, having detected that the player has decided to take a goalkeeper-dependent strategy, waiting for the goalkeeper to move to decide where to shot, it is relevant to know that, in this type of situation, it is easier for players to hit with the inside to their unnatural side (Chiappori et al., 2002).

The aim of this study is to analyse the interaction between players and goalkeepers in penalty kicks taken in international team competitions, which allows the goalkeeper to obtain relevant information about the area of the goal to which the kick is going to be directed from the information extracted at different moments of the kick. The objective will be met by using a diachronic analysis technique, the lag sequential analysis, which is among those recommended by researchers of observational methodology (Bakeman & Quera, 2011), and which makes it possible to detect regular behavioural structures within the records that make up the observational sample.

METHOD

Research design

Within the observational methodology (Anguera, 1979), an observational design has been carried out (Anguera et al., 2011): nomothetic, by analysing the performance of 149 players and 66 goalkeepers; intersessional follow-up -185 penalties shot in international team competitions- and intrasessional follow-up -the behaviours developed by the player and goalkeeper in each penalty kick, *frame by frame*-; and multidimensional, with proxemic and gestural dimensions.

Participants

In the present study all penalties (n=185) of the following competitions have been analyzed: Eurocup '21 (n=55), American Cup '21 (n=36), Asian Cup '19 (n=35), African Cup '19 (n=48) and Gold Cup '21 (n=11). The images of the penalties have been taken from the official channels of the different official accounts of the competitions. UEFA (@uefa), CONMEBOL (@conmebol), AFC (@afcasiacup), CAN (@caftvafricanfootball), and CONCACAF (@concacaf).

All the penalties sampled were taken after the modification in 2019 of Article 14 by the International Football Association Board, whereby the goalkeeper must have at least one foot on the goal line at the moment of the penalty kick. In 2022, this rule was amended to clarify that the foot may also be on or behind the line.

This study has been approved by the Research Ethics Committee of the University of La Rioja (file no. 43-2023). This article is part of a thesis by compendium of publications. That is why the penalties under analysis and the observational instrument are the same as in Barbero et al. (2023).

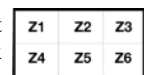
Observation instrument

In this study we have used the observation instrument for the analysis of player-goalkeeper interaction in penalty kicks designed by Barbero et al. (2023). The observation instrument (Table 1) is a combination of field format and category systems (Anguera et al., 2007).

Table 1.

Observation instrument: dimensions, category systems and codes.

No.	Dimension	Category systems and codes
1	Competition	European Championship (CEC), Copa América (CCAM), Africa Cup of Nations (CCAF), AFC Asian Cup (CCAS), Concacaf Gold Cup (CCO)
2	Match Time	0-30´ (TI), 31-60´ (TM), 61-90+ (TE), Extra time (TET), Penalty shootout (TPS)
3	Match Score (in relation to the kicking player)	Winning (MSW), Drawing (MSD), Losing (MSL)
4	Match Result (in relation to the kicking player)	Won (MRG), Drawn (MRD), Lost (MRL), Penalty shootout (MRPS)
5	Start of kicker’s run-up in relation to the ball	Right (SRR), Middle (SRM), Left (SRL)
6	Goalkeeper’s actions prior to the kick	No movement (GNM), Lateral movements (GML), Arm movements (GAM), Jumps (GJ), Crouches (GC), Moves forward (GMF)
7	Movements in the kicker’s run-up	Skipping (MKS), Sudden stop (MSS), Change of pace (MCP)
8	Speed of kicker’s run-up	Fast – with flight phase (SF), Slow – without flight phase (SS)
9	Length of kicker’s run-up	up to 3 steps (LKS), More than 3 steps (LKL), From outside the area (LKOA)
10	Direction of kicker’s supporting foot	To the left of the goalkeeper (DSFL), To the middle (DSLML), To the right of the goalkeeper (DSFR)
11	Position of opposite arm to kicker’s kicking foot	Arm outstretched and open (OAO), Arm close to body (OAC), Arm open with elbow bent (OAEF), Arm half-open (OAHO)
12	Kicker’s kicking foot	Left (LF), Right (RF)
13	Kicker’s contact surface	Interior (CSI), Exterior (CSE), Instep (CSIN)
14	Goalkeeper’s position when kick is taken	Defeated to the left (GPL), Defeated to the right (GPR), In the middle (GPM)
15	Shot trajectory	Rectilinear (STR), Parabolic (STP)
16	End zone of kick	Z1 and Z4, left sector; Z2 and Z5, middle sector; Z3 and Z6, right sector. Dimensions in metres: (sector: 2.44 x 2.44; zone: 2.44 x 1.22)
17	Result of kick	Goal (RG), Goalkeeper blocks (RGB), Crossbar or post (RP), Miss (RM)



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Recording and coding

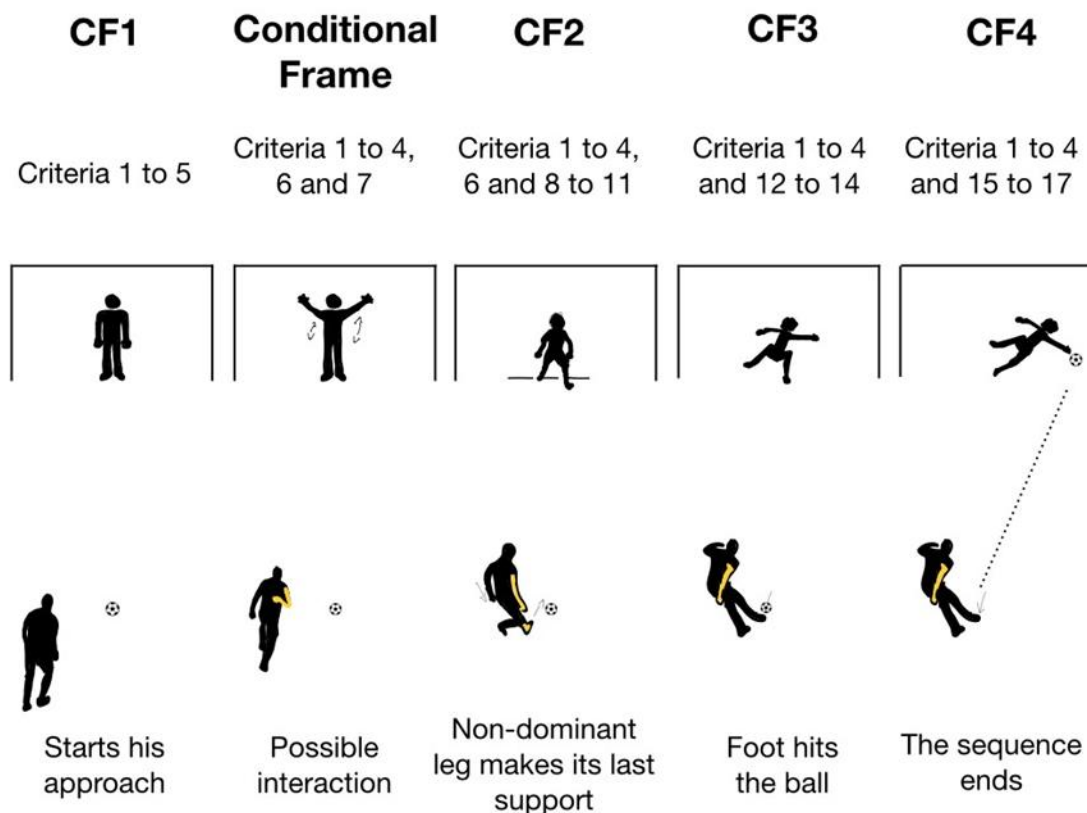
LINCE software, version 1.4 (Gabin et al., 2012), was used for the recording and coding of the 185 penalties analysed. LINCE software is free and can be downloaded at <http://lom.observesport.com/>. The recording is structured around four key moments or critical frames (figure 1):

- Critical frame 1: corresponding to the moment when the player starts his approach to the ball; criteria 1 to 5 are recorded.
- Critical frame 2: corresponding to the moment when the non-dominant leg makes its last support before the shot; criteria 1 to 4, 6 and 8 to 11 are recorded.
- Critical frame 3: corresponding to the moment when the foot hits the ball; criteria 1 to 4 and 12 to 14 are recorded.
- Critical frame 4: corresponding to the moment when the sequence ends, "goalkeepers blocks", "crossbar or post", "goal" or "miss"; criteria 1 to 4 and 15 to 17 are recorded.

In addition, while the player is approaching the ball, between critical frame 1 and critical frame 2, the possible interaction between player and goalkeeper is recorded -criteria 1 to 4 and 6 and 7 are recorded-. These records are not considered key but "conditional frames" -they may or may not happen- (Garzón et al., 2011), and focus on the interaction between player and goalkeeper.

Figure 1.

Recording structure based on the observation instrument.



Data reliability

This study provides evidence of reliability by determining intra-observer and inter-observers agreement. In this sense, two observers -once satisfied with the observer training process from Arana et al. (2016)- were responsible for carrying out the searches. The first observer recorded the whole observational sample. Then, in order to support both intra- and inter-observers agreement, both observers recorded 21 penalties (11.35% of the total). Table 2 presents the agreement percentage and the Cohen's Kappa coefficient, corresponding to the data package composed of the 21 penalties, calculated using GSEQ software (Bakeman & Quera, 2011). The values obtained for Cohen's Kappa coefficient (1960) indicate near perfect agreement, in accordance with Landis and Koch's (1977) classification.

Table 2

Intra-observer and inter-observer agreement.

Intra-observer agreement 1st observer		Intra-observer agreement 2nd observer		Inter-observers agreement	
Kappa	% Agreement	Kappa	% Agreement	Kappa	% Agreement
0.94	94%	0.89	89%	0.86	86%

Data analysis

The data analysis options are diverse. While Barbero et al. (2023) focused essentially on finding the Cramer's V and the detection of T-patterns, this article focuses on the diachrony of the interaction between the kicker and the goalkeeper, grouping all penalties that make up the sample, without addressing the specificity of each competition. A lag sequential analysis (Bakeman, 1978) was performed using GSEQ software (Bakeman & Quera, 2011). This software has a robust conceptual support, is free and can be downloaded at <https://www.mangold-international.com/en/products/software/gseq.html>. The GSEQ software facilitates the calculation of the adjusted residuals in the lags that are determined; in our case, from lag -5 to lag 0 or co-occurrence corresponding to critical frame 4, which incorporates the consequence of the shot, which allow us to detect the statistically significant differences existing between the conditioned (from the observed frequencies) and unconditioned (from the expected frequencies) probabilities, between *given* and *target* behaviours.

For the analysis of the behaviour displayed in the critical frames, we have taken as *given* behaviours those corresponding to the "end zone of kick" dimension and as *target* behaviours: in lag 0 or co-occurrence (critical frame 4) the criteria "shot trajectory" and "result of kick"; in lag -1 (critical frame 3) the criteria "kicker's kicking foot" and "kicker's contact surface"; in lag -2 (critical frame 2) the criteria "goalkeepers actions prior to the kick", "speed of kicker's run-up", "length of kicker's run-up", "direction of kicker's supporting foot" and "position of opposite arm to kickers kicking foot"; in lags -3, -4 and -5 (critical frame 1) the criteria "match time", "match score", "match result" and "star of kicker's run-up in relation to the ball". For the analysis of the interaction between kicker and goalkeeper provided by the conditional frames, the categories corresponding to the criteria "goalkeepers actions prior to the kick" and "movements in the kicker's run-up" will be taken as *target* behaviours in lags -3, -4 and -5.

RESULTS

The results obtained from the lag sequential analysis are presented below. Both for the dimensions analysed in the critical frames and in the conditional frames, those corresponding to the dimension "end zone of kick" have been taken as *given* behaviours (see tables 3 and figures 2 and 3). It should be recalled that the goal zones are numbered from left to right from the kicker's perspective (zones 1, 2 and 3 are the upper zones and 4, 5 and 6 are the lower zones).

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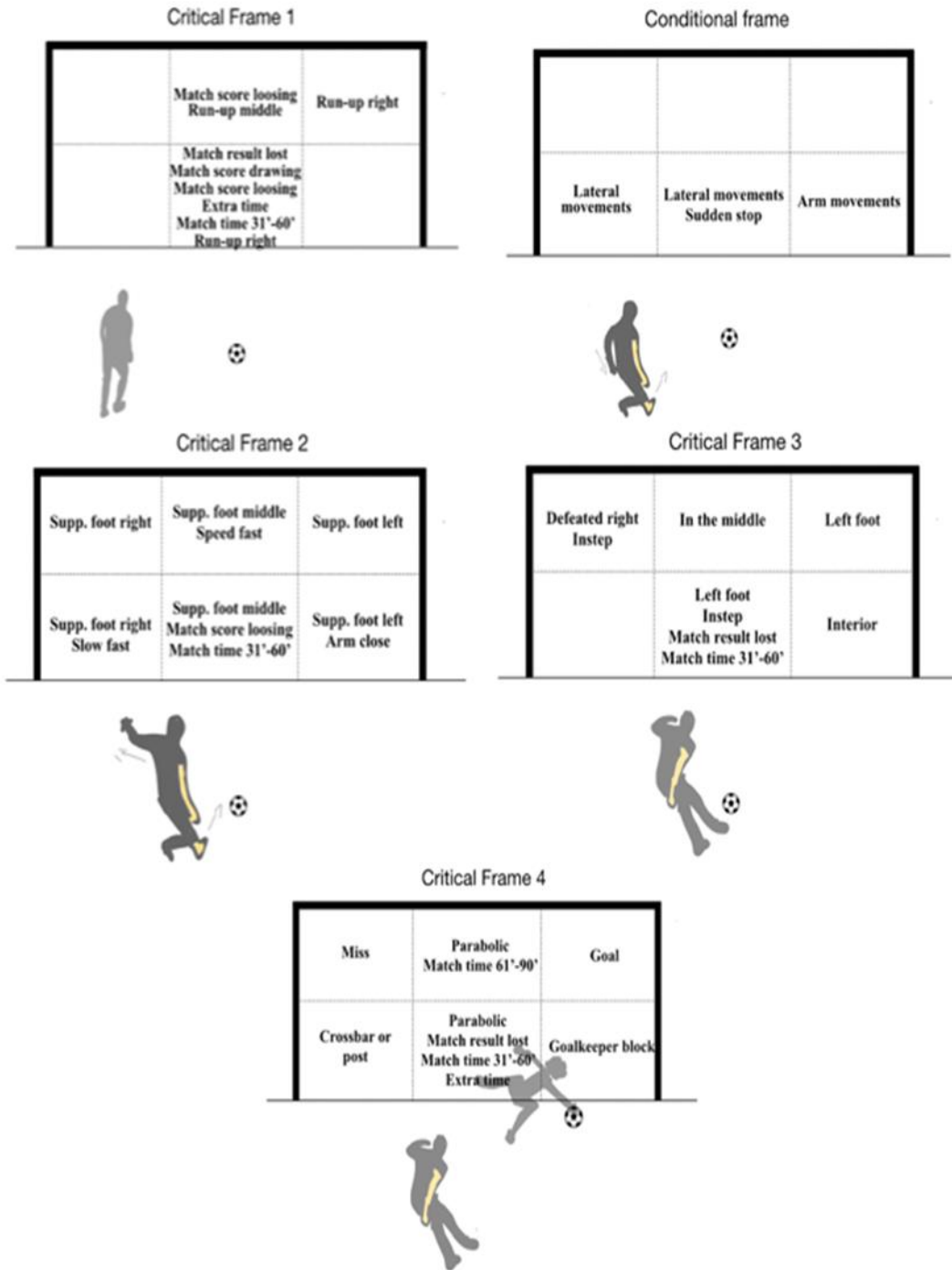
Table 3

Lag sequential analysis between the given categories of the "End zone of kick" dimension and the target behaviors. For each critical frame, the lag in parentheses and the adjusted residuals after the = sign are shown.

Zone	Critical frame 1	Conditional frames (LAG -3,-4, -5)	Critical frame 2 (LAG-2)	Critical frame 3 (LAG -1)	Critical frame 4 (LAG 0)
Z1	MSW(L-3)= -2.05		DSLML= -2.32 DSFR= 5.42 DSFL= -4.25	GPR= 2.80 GPL= -2.54 CSIN= 3.89 CSI= -3.89	RM= 5.22 RG= -2.00
Z2	MRL(L-5)= 2.51 MSL(L-5)= 2.51 SRM(L-5)= 3.26 SRM(L-4)= 3.67 SRM(L-4)= -2.45		DSLML= 9.69 DSFR= -3.84 DSFL= -2.72 SS=-2.49 SF= 2.49	GPM= 2.29	STP= 2.39 TE= 2.09
Z3	SRR(L-3)= 2.35 SRL(L-3)= -2.94		DSFR= -3.78 DSFL= 4.65	RF= -2.73 LF= 2,73	RG= 2.26 RM= -2.14
Z4		GML(L-5)= 2.45	OAC= -2.60 DSFR= 5.84 DSLML=-2.32 DSFL= -4.16 SS= 2.48 SF= -2.48		RP= 2.42
Z5	MRPS(L-5)= -2.27 MRL(L-5)= 5.41 MRL(L-4)= 2.40 MRL(L-3)= 2.21 MSD(L-5)= 2.71 MSL(L-5)= 5.41 MSL(L-4)= 2.40 TET(L-4)= 2.06 TE(L-4)= -2.10 TM(L-3)= 2.34 TE(L-3)= -2.76 SRR(L-5)= 2.44	MSS(L-3)= 2.47 GML(L-5)= 2.36	DSLML= 5.72 DSFL= -1.98 MSL= 2.22 TM= 2.34 TE= -2.76	RF= -2.33 LF= 2,33 CSIN= 1,98 CSI= -1.98 MRL= 2.22 TM= 2.34 TE= -2.76	STP= 2.51 MRL= 2.22 TM= 3.42 TET= 2.51
Z6		GAM(L-5)= 2.17	OAO=-2.79 OAC=4.94 DSLML= -3.02 DSFR= -5.66 DSFL= 8.26 GNM= -2.07	CSIN=-4.69 CSI= 4.69	RGB= 1.97

Figure 2

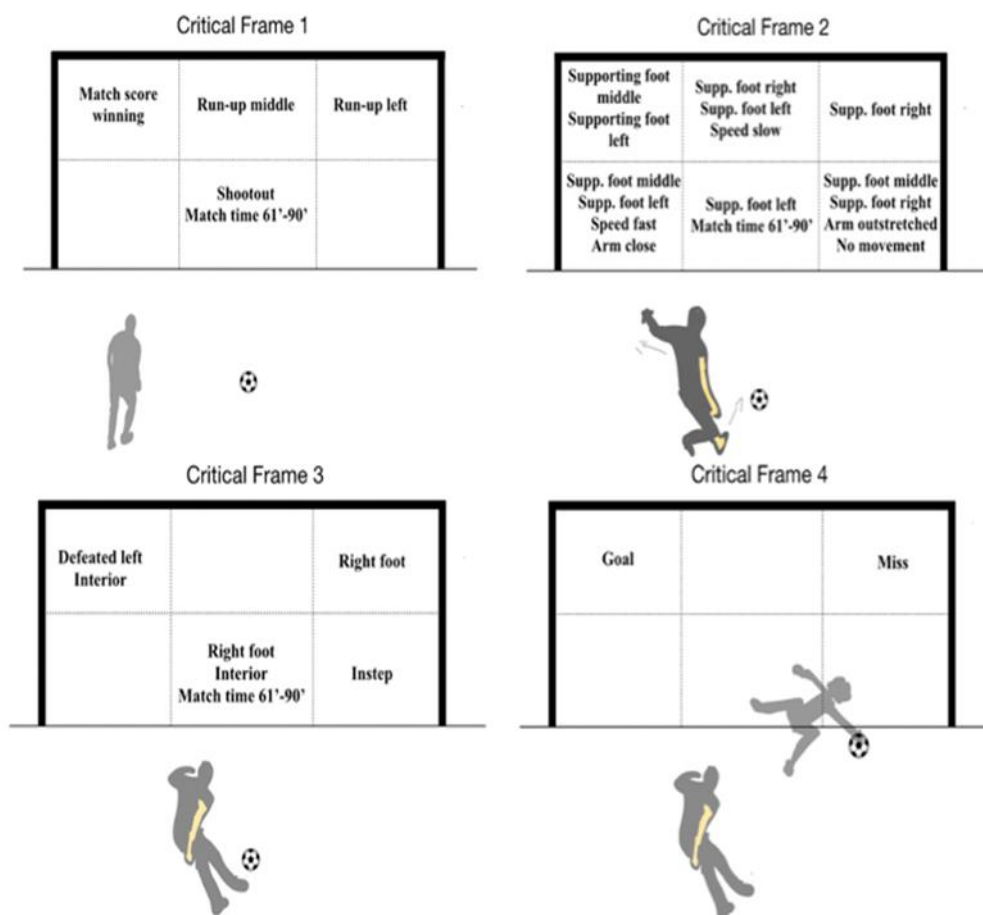
Graphic representation of the results obtained from the lag sequential analysis (activation).



Interaction between kicker and goalkeeper in penalty kicks

Figure 3

Graphic representation of the results obtained from the lag sequential analysis (inhibition).



DISCUSSION

The aim of this study is to carry out an analysis of the interaction between kickers and goalkeepers in penalty kicks taken in international team competitions, which allows the goalkeeper to obtain relevant information about the area of the goal to which the kick is going to be directed from the information extracted at different moments of the kick.

For data collection, due to its suitability to meet the objectives of this study, we have used the observation instrument of Barbero et al. (2023), which has proven evidence of validity and reliability. The reliability of the records supporting this work has been guaranteed by intra-observer and inter-observer agreement.

The observation instrument allows us to obtain information from the context and behaviours displayed by the player and goalkeeper throughout their interaction in the penalty kick. The record is structured in four key moments

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called critical frames; but, in addition, between critical frames 1 and 2, there may be other conditional frames resulting from the interaction between pitcher and goalkeeper.

Given the diachronic structure of the record obtained from the observation instrument, we have resorted to one of the most relevant diachronic analysis techniques in observational methodology, namely the lag sequential analysis with the GSEQ software.

Critical frame 1 is recorded at the moment the player begins his approach to the ball. Corresponds to lags -5, -4 or -3. In this critical frame 1, the contextual dimensions are collected, which constitute the first relevant information that the goalkeeper can have before the duel even starts. It has been found significant activation between match score -for the player- "lossing" (MSL) and the kick being directed to the centre sector (Z2 and Z5) and between match score "drawing" (MSD) and the kick being directed to zone 5. Closely related to the above, an association has also been detected between match result "lost" (MRL) and the central sector (Z2 and Z5). According to Brinkschulte et al. (2023) when the kicking player is losing, they tend to secure the shot; in this sense and according to Bar-Eli et al. (2007) kicks aimed at the centre sector are more effective than those aimed at the sides. In turn, inhibition relationships have been found between match score "win" (MSW) and throwing to the upper left zone (Z1); this destination, despite being a good option to send the kick as it is one of the zones in which goalkeepers make fewer saves (Bar-Eli & Azar, 2009), entails greater technical difficulty that may explain the inhibition (Navarro et al., 2013).

Continuing with the contextual dimensions, our results show how, with playing time, preference changes in terms of the area to which penalty kicks should be directed. The time in which the penalty is located conditions the perception of risk, which increases in pressure situations (Brimmell et al., 2019; Ellis & Ward, 2022). A relationship of association has been found between penalty kicks taken in minutes "31-60" (TM) to the lower central zone (Z5). However, this activation relationship with the lower central zone (Z5) becomes an inhibition relationship in the final minutes of the match "61 to 90+" (TE) with the whole central sector (Z2 and Z5). However, in the extra time (TET) the activation relationship with the lower central zone (Z5) is recovered; which could be related to the fact that the player prefers to take the risk of the goalkeeper stopping his shot rather than the ball going out of the goal (Bar-Eli et al., 2009).

As a result of the information provided by the critical frame 1 regarding the place of "start of kicker's run-up in relation to the ball", a relationship of association has been found for players with right lateral preference between the "start of kicker's run-up middle" (SRM) and the upper central zone (Z2) and of inhibition to throw to this same zone for those with left lateral preference. Activation has also been noted among "start of kicker's run-up right" and that the shot is directed to the lower centre zone (Z5). These results can be justified by the findings of Williams and Griffiths (2002) that approaching the ball, on the same imaginary line that links goal-ball-kicker, biomechanically limits shots to the unnatural side as it involves changing the opening angle of the hips just before the kick. In this study all players who started their run to the left of the ball showed right lateral preference and those who started to the right of the ball were left lateral preference kickers. The upper right zone (Z3) has had activation relationships with start of kicker's run-up "right" (SRR) and inhibition relationships with start of kicker's run-up "left" (SRL). Our results are in line with those of Palao et al. (2010) who, despite not finding statistically significant differences, found a tendency for shots to be kicked to the natural side of the player -players with a right lateral preference to his left and those with a left lateral preference to his right-.

The recording of the conditional frames has allowed us to capture the interaction between player and goalkeeper. In relation to the movements prior to the goalkeeper's kick, a relationship of activation has been found when the goalkeeper performs "lateral movements" (GML) and the penalty kick is directed to the lower left zone (Z4) and lower centre (Z5); also between "arm movements" (GAM) and the kick is directed to the lower right zone (Z6). In this regard, Wood and Wilson (2010) argue that kickers decrease the effectiveness of their shots when goalkeepers make distracting movements; Van der Kamp and Masters (2008) assert that these prior movements by the goalkeeper contribute to the player's tendency to adjust kicks closer to the post or crossbar; and Furley et al. (2017) advise to perform these distraction movements by concluding that the player who fixes his gaze on the goalkeeper tends to throw closer to the goalkeeper.

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Regarding the player's pre-shot movements, an activation relationship has been detected in that when the player performs a "sudden stop" (MSS) the kick is directed to the lower centre zone (Z5). This behaviour is related to a goalkeeper-dependent throwing strategy; according to Noël et al. (2021) 27.33% of shots are taken with this strategy, in order to make the goalkeeper tend to go to one of the sides and thus be able to shoot to the open side or to the centre.

The information contained in critical frame 2 corresponding to the moment when the non-dominant leg makes its last support before the kick (lag -2) -a moment of the kick in which the goalkeeper still has time to hold his movement and decide where to throw- has revealed the activation relationship between speed of kicker's run-up "fast" (SF) and the kick being directed to the upper centre zone (Z2); shots in which this behaviour is manifested are related to a powerful hit within a goalkeeper-independent strategy (Hunter 2022; Noël et al., 2021; Prieto-Lage et al., 2020). On the other hand, an association has been detected between speed of kicker's run-up "slow" (SS) and the shot being executed in the lower left zone (Z4). This behaviour is related to a goalkeeper-dependent strategy (Noël et al., 2021) and a throw to the natural side, sometimes motivated by the goalkeeper having held his movement leaving the kicker no time (Van der Kamp, 2006).

The dimension "direction of kicker's supporting foot", as in other studies (Navia et al., 2017; Zheng et al., 2021), also provides relevant information to help the goalkeeper anticipate the location of the kick. In this work we have found very clear activation relationships between: "to the middle" (DSL M) and shots aimed at the central sector areas (Z2 and Z5); "to the left of the goalkeepers" (DSFL) with shots aimed at the right sector (Z3 and Z6); and "to the right of the goalkeepers" (DSFR) with shots aimed at the left sector areas (Z1 and Z4). Although by itself this dimension direction of kicker's supporting foot is not a reliable indicator (Diaz et. al., 2012) the combination with other previous actions, such as the position of opposite arm to kicker's kicking foot, increases the possibility of success (Nadal et al., 2018).

The information regarding the position of opposite arm to kicker's kicking foot is very relevant for the goalkeeper to anticipate the place in the goal where the kick will be aimed. Among "arm close to body" (OAC) we have detected, on the one hand, a relationship of activation with the shot being directed to the lower right zone (Z6); and, on the other hand, a relationship of inhibition with the lower left zone (Z4). This finding points in the same direction as the results of Nadal et al. (2018) and Buscà et al. (2022) in which, if the arm is close to the body, the ball tends to be directed to the side of the dominant leg -unnatural side for the kicker-.

Critical frame 3 (lag -1) is recorded the moment when the player hits the ball. Different authors (Diaz et al., 2012; Lopes et al., 2014; Morya et al., 2005; Van der Kamp et al., 2018) recommend that the goalkeeper should hold his movement, as long as possible, to obtain as much relevant information as possible; once the player hits the ball, the goalkeeper will need more time to get to a tight ball than is available to them (Navia et al., 2017). Regarding the kicker's contact surface dimension, the activation relationship between hitting the ball with the "instep" (CSIN) and the kick being directed to the upper left zone (Z1) or to the lower central zone (Z5) was found. This instep kick to these areas is related to the increased speed of the ball with this contact surface (Levanon & Dapena, 1998), and the goalkeeper may not have enough time to reach the ball if they wait for this moment (Savelsbergh et al., 2005); although according to Egan et al. (2007) the goalkeeper has an indication that the direction of the "instep" kick (CSIN) is related to the direction of the player's approach run to the ball. In relation to penalty kicks in which the kicker hits with the "inside" (CSI), an activation relationship has been detected with the lower right zone (Z6); with this contact surface greater precision is obtained in the kick (Lees et al., 2010), hence it is the one used in kicks in which the player tries to adjust the ball to the post.

In critical frame 3 the laterality corresponding to the foot used by the kicker is also recorded. This information can be handled by the goalkeeper before the kick. In the present study we have detected the association between left-footed (LF) players directing the kick to the upper right (Z3) and lower central (Z5) zones and inhibition of right-footed kicks to these same zones. In line with our results Palao et al. (2010) found a predominance, although not statistically significant, of players with left lateral preference throwing to the right sector and with right lateral preference throwing to the left sector.

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Continuing with the information contained in critical frame 3, the dimension "goalkeeper's position when kick is taken" informs us of the direction the kick takes based on the goalkeeper's behaviour. An activation relationship has been found between "defeated to the right" (GPR) and the upper left zone (Z3) and another of inhibition between the same zone and "defeated to the left" (GPL). These results are in line with those of Chiappori et al., (2002), in which goalkeepers tend to move to the left sector when a right-footed player throws and to the right sector when a left-footed player throws. Bar-Eli et al. (2007) refer to the fact that few goalkeepers choose to cover the central areas; however, in our study we have detected an association relationship between "defeated to the middle" (GPM) and shots to the upper centre area (Z2), which reflects that goalkeepers have learned to anticipate this type of shots.

In critical frame 4 (lag 0), the "ball trajectory" dimension allowed us to observe the activation relationship between shots with a "parabolic" trajectory (STP) with the zones that constitute the centre sector (Z2 and Z5); this result is related to the so-called "Panenka" shots that take into account that goalkeepers choose to cover one of the sides more often than the centre sector (Bar-Eli et al., 2007; Palacios-Huerta, 2003); and which have a higher probability of scoring than a throw to the side (Chiappori et al., 2002). But if the goalkeeper decides to wait for his movement until he checks the trajectory of the ball, he will have a good chance of success (Bar-Eli & Azar, 2009); we recall that this behaviour, favourable to the goalkeeper, has already been detected in the present work.

This critical frame 4 also provides information relevant to the consequence of the shot. In particular, association relationships have been found between kicks sent to the lower right zone (Z6) and the result of kick "goalkeepers blocks" (RGB). This result can be related to: the conclusions of Almeida and Volossovitch (2023) that penalty kicks aimed at the lower areas of the goal -more frequent than those aimed at the upper areas (López-Botella & Palao, 2007)- increase the probability of success of goalkeepers; with the lower effectiveness of penalty kicks aimed at the right sector found by Palao et al. (2010); and with the greater efficiency obtained by goalkeepers when diving into zone 6 (Furley et al., 2017). On the other hand, an activation relationship has been found between the consequence "miss" (RM) and "crossbar or post" (RP) and penalties taken in the left sector (Z1 and Z4); these results are in line with the lower effectiveness of penalties taken in the left sector found by López-Botella and Palao (2007).

The major limitation of this work was the lower proportion of left-leg penalty kickers. Specifically, in this work the percentage was 22,16%. We are working to obtain an observational sample of kickers with left leg laterality. However, it is relevant to remember that the observation instrument allows a diachronic analysis that takes into consideration the laterality with which the player performs the kick.

PRACTICAL APPLICATIONS

Based on the sequential analysis carried out on the interaction between goalkeepers and players, this paper concludes with a series of relevant guidelines that can be used by goalkeeping coaches, analysts, etc. to help their goalkeepers deal with a penalty kick. Considering the penalty context information, the goalkeeper is advised to hold as long as possible in the centre of the goal if the score is tied or in his favour, as well as in penalty kicks shot from the 31st to the 60th minute and in extra time situations. It is also an effective strategy if the player taking the penalty kick starts from the centre, on the imaginary line connecting goal-ball-kicker.

When the player starts the run, if the goalkeeper makes lateral movements above the goal line, holding in the centre or diving to the bottom left zone are the recommended options; while if the goalkeeper makes arm movements it is associated with a shot to the bottom right zone. If the player's approach run to the ball is fast or during the approach run the player makes a sudden stop, a good option for the goalkeeper is to hold in the centre. In the case of a slow approach run, the goalkeeper should hold as long as possible before diving to the bottom right if the start of kicker's run-up in relation to the ball is left; and to the bottom right, if the start of kicker's run-up in relation to the ball is right.

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The direction of the player's supporting foot is a decisive piece of information, and it is suggested that the goalkeeper faces the sector where the supporting foot is pointing. Continuing at the moment when the non-dominant leg makes its last support before the strike, if the arm opposite to the foot with which the player makes the shot is close to the body, the goalkeeper is advised to throw towards the lower right sector, especially if the player is right-handed.

Once the player hits the ball, the goalkeeper will need more time to get to a tight ball than is available to him; if the shot is made with the instep, the relationship of association has been found with the upper left zone or the lower centre; whereas if the shot is made with the inside, the relationship is established with the lower right zone, especially in the case of right-handed throwers.

In the event that, despite all these indications, the goalkeeper has not been able to decide the area to which the kick is to be directed, a favourable option is to go to the lower area corresponding to the thrower's natural side -players with right lateral preference to his left and those with left lateral preference to his right-.

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