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Penalty kick outcomes in UEFA club competitions (2010-2015): The roles of situational, individual and performance factors

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Abstract

This study aimed to investigate main and interaction effects of situational (competition phase, match location, match status and match period), individual (penalty taker's footedness, playing position, and age difference to the goalkeeper), and performance factors (shot direction and goalkeeper's action) on penalty kick outcome in UEFA Champions and Europa leagues. Data were collected from soccer Internet sites and TV broadcasts during five consecutive seasons (from 2010-2011 to 2014-2015). A total of 536 penalties were recorded and analysed considering the aforementioned three groups of variables and the respective penalty outcome (goal, saved or missed). Multinomial logistic regression analysis was used to assess the effects of factors on penalty outcome. The logistic regression model revealed the probabilities of penalty kicks being saved significantly increased (1) in the middle of matches (30:01–60:00) and (2) when the shots were directed to lower zones of the goal, in particular to the lower centre-left zone of the goal (penalty taker's perspective). Besides, the odds of missing the penalty substantially increased when the shot aimed the high zones of the goal. Based on the current findings, penalty takers should be encouraged to direct the shot to the upper corners of the goal and goalkeepers should wait longer in order to dive to the correct side of the ball. Although performance factors were the most decisive for determining the penalty outcome, situational factors such as match period may also influence the success of penalty kicks.

Key words: soccer, notational analysis, performance, situational variables, logistic regression.

1. Introduction

The penalty kick is a very peculiar event of direct confrontation between two opponents (penalty taker and goalkeeper) during a soccer match. Notably, there has been an increase in research examining these match events in the last few years (Lopes *et al.*, 2014a). Penalty kicks have been mainly analysed in two contexts: 1) in laboratory or other non-game and well-controlled settings (video-simulation tasks and in-situ

experimental conditions), aiming the analysis of perceptual, physical and strategic aspects of performance (e.g., Savelsbergh *et al.*, 2002; Dicks *et al.*, 2010; Lopes *et al.*, 2012; Weigelt and Memmert, 2012; Navarro *et al.*, 2013), and 2) in-game situations, enabling the identification of prominent factors that affect both players' performances and the penalty kick outcome (e.g., Chiappori *et al*., 2002; Jordet *et al.*, 2007; White and O'Donoghue, 2013). While in the first context researchers progressively tried to increase the task representativeness searching for new methods to improve the performance and strategies of penalty takers and goalkeepers, in the second researchers attempted to improve data collection procedures based on televised matches. Indeed, the major strength of these latter studies rests on the high ecological validity of assessing elite performers in a real-world sport competition (Jordet *et al.*, 2009).

Relatively few goals are usually scored from penalty kicks in elite soccer. For instance, Gelade (2014) found that only 7.7% of goals, scored in the English Premier League between 2006 and 2012, were penalty goals. Despite that, the number of goals scored in a regular soccer match is quite small (2.5 on average), and so a penalty kick can play a decisive role in some matches, and even in the final classification of a championship/tournament (Morya *et al.*, 2003; Bar-Eli and Azar, 2009; Fariña *et al.*, 2013). Thus, neither researchers nor coaches should neglect the importance of investigating and practicing penalty kicks in high-level competitive standards. Most studies have reported success rates of penalty kicks in professional soccer between 70 and 80.5% (e.g., Bar-Eli *et al.*, 2007; Palao *et al.*, 2010; White and O'Donoghue, 2013). The unsuccessful penalties are normally a consequence of saves by the goalkeeper (15-20%) or missed shots (5-10%) (Hughes and Wells, 2002; Jordet *et al*., 2007).

The penalty kick outcome (goal, saved or missed) has been investigated in relation to numerous factors, such as performance (e.g., shot direction, goalkeeper's dive side), strategic (e.g., keeper-independent/dependent strategies), situational (e.g., match time, match status), individual (e.g., footedness, age, positional role), perceptual (e.g., visual search behaviours) or psychological (e.g., team status, kick importance). However, the advantage in a penalty kick is clearly on the penalty taker's side (Fariña *et al.*, 2013), in particular if he/she is a specialist (López-Botella and Palao, 2007). Hence, when assembled a large number of these instances during several matches, it is rare to find direct associations between most of the aforementioned factors and the penalty outcome. While higher success rates on penalty kicks have been observed (1) with the keeper-independent strategy (Noël *et al.*, 2015), (2) in left-footed players (López-Botella and Palao, 2007; Palao *et al.*, 2010), (3) in younger players, forwards and with less minutes played (Jordet *et al.*, 2007), and (4) in the second halves (White and O'Donoghue, 2013), the differences between penalty outcomes relatively to the other categories (keeper-dependent strategy, right-footed players, older players, midfielders and defenders, more minutes played, and first halves, respectively) have not reach statistical significance. On the contrary, performance factors as shot direction (López-Botella and Palao, 2007; Bar-Eli and Azar, 2009; White and O'Donoghue, 2013) and goalkeeper's action (Bar-Eli *et al.*, 2007; Fariña *et al.*, 2013) have been found to be highly associated with the penalty outcome. Generally, the probability of the ball being saved by the goalkeeper tends to decrease when the shot is directed to the high zones of the goal, but the 'miss factor' remains (Hughes and Wells, 2002; Bar-Eli and Azar, 2009; Palao *et al.*, 2010). Disregarding the vertical direction, whilst some studies

suggested shooting to the centre of the goal as the best strategy (Chiappori *et al.*, 2002; Bar-Eli and Azar, 2009), others stated that these zones are not safe for shots unless the goalkeeper starts to move too early (Fariña *et al.*, 2013).

Although the penalty outcome depends, above all, on the performance emerging from the 'penalty taker - goalkeeper' dyadic interactions (Lopes *et al.*, 2012), diverse situational and individual/personal constraints must mediate its effectiveness (Noël *et al.*, 2015). The effects of many of the referred factors on the penalty outcome have not been studied sufficiently and others have not been studied yet. For instance, some researchers have claimed that situational factors may affect the psychological status of players and, consequently, the outcome of a penalty kick (Chiappori *et al.*, 2002; Bar-Eli *et al.*, 2007; Jordet *et al.*, 2007). However, as far as we know, the effect of match location (i.e., whether a team is playing at its own or at the opponents' ground) on penalty outcome has never been examined, while the influence of match status (i.e., whether a team is winning, drawing or losing) and match time has only been briefly touched in previous research (Chiappori *et al.*, 2002; White and O'Donoghue, 2013). Jordet *et al.* (2007) analysed the effects of penalty takers' age but without considering the age difference between both players composing this dyadic system.

Thus, this exploratory study aimed to investigate main and interaction effects of situational (competition phase, match location, match status and match period), individual (penalty takers' footedness, playing position, and age difference to the goalkeeper), and performance factors (shot direction and goalkeeper's action) on penalty outcomes in matches of the most important international club competitions in Europe: UEFA Champions League and Europa League.

2. Methods

2.1. Sample

The sample of this study consisted of all penalty kicks awarded by the referees in the play-offs, group stages and knockout phases of UEFA Champions League and Europa League over a period of five consecutive seasons (from 2010-2011 to 2014-2015). The formats of both competitions remained unchanged throughout these seasons. In order to collect data perfectly balanced in terms of home and away matches, the finals (neutral ground), the periods of extra-time and the penalty shoot-outs were not considered for the analysis. The Table 1 presents some sample-related details for each competition.

Table 1. Sample-related details (n) displayed by phase in each UEFA club competition.

	Champions League			Europa League			Total
	Play-offs	Group Stage	Knockout Phase	Play-offs	Group Stage	Knockout Phase	
Matches	100	480	140	334	720	300	2074
Goals	263	1370	402	906	1900	760	5601
Penalty Kicks	25	141	34	84	180	79	536

Therefore, from 2074 matches, which corresponded to the selection criteria (Champions League: n = 720; Europa League: n = 1354), a total of 536 penalty kicks were

identified, recorded and notated post-event. The penalty kicks were taken by a total of 332 specialists players, 261 (78.6%) right-footed and 71 (21.4%) left-footed. Approval for the study was granted by the local University Ethics Committee.

2.2. Data Collection Procedures

Data were collected from publicly available soccer Internet sites and TV broadcasts during the aforesaid seasons of Champions and Europa leagues. The Microsoft Excel 2010 (Microsoft® Corporation, USA) was used to gather all the information regarding situational (competition, competition phase, teams, match date, match location, match status, and match period), individual (footedness, playing position, penalty taker's name and birth date, goalkeeper's name and birth date, and age difference between the penalty taker and the goalkeeper) and performance (shot direction and goalkeeper's action) factors, as well as the penalty kick outcome (dependent variable).

The situational and individual data were retrieved from the official website of UEFA (*www.uefa.com*) and confirmed in two other Internet sources (*www.zerozero.pt* and *www.wikipedia.org*) in order to avoid errors resulting from the use of a single source (Collet, 2013). Table 2 exhibits how situational and individual variables were operationalised in this study.

Table 2. Definition of situational and individual variables and collection procedures.

	Variables	Categories	Definition and/or collection procedures
Situational	Competition Phase	1) Play-offs 2) Group Stage 3) Knockout Phase	Registered as 1, 2 or 3 depending on the phase in which the match was played.
	Match Location	1) Home 2) Away	Registered as 1 or 2 depending on whether the team awarded with the penalty kick was playing at home or away.
	Match Status	1) Winning 2) Drawing 3) Losing	Represents the evolving score of a match (group stage) or two-legged tie (play-offs and knockout phase) at the instant the penalty kick was awarded. Episodes were registered as 1, 2 or 3 according to the number of goals scored and conceded by the team awarded with the penalty kick, and respecting the specific rules of UEFA competitions (e.g. away goals rule).
	Match Period	1) 00:01 – 30:00 2) 30:01 – 60:00 3) 60:01 – 90:00	Registered as 1, 2 or 3 depending on the match time in which the penalty kick was performed.
Individual	Footedness	1) Right-footed 2) Left-footed	Registered as 1 or 2 as a function of the foot used by the penalty taker to shoot the ball.
	Playing Position	1) Defender 2) Midfielder 3) Forward	Registered as 1, 2 or 3 based on the playing position performed by the penalty taker in that specific match. Note: goalkeepers were notated as defenders.
	Age difference to the goalkeeper	1) Younger [≤ -3.1 years] 2) Similar age [-3.0 – 3.0 years] 3) Older [≥ 3.1 years]	Registered as 1, 2 or 3 based on the difference of the decimal ages of penalty taker and goalkeeper. The decimal ages were calculated taking the birth dates and the date of the match in which the penalty kick occurred as references. Note: the decimal age formula (see Willekens, 2013) used in the Microsoft Excel 2010 file was: = (match date cell – birth date cell)/365.25

These factual data were assembled prior to the notation of performance-related variables. All data related to penalty kicks performances and respective outcomes were collected by the same observer (i.e., the first author; more than 5 years of experience in performance analysis techniques) from the observation of video footage of the penalty kicks. The video footage was compiled using recordings of televised match highlights displayed in Internet sites such as *www.youtube.com*, *www.dailymotion.com*, *www.footytube.com*, *www.okgoals.com*, *www.zerozero.pt*, and *www.tvgolo.pt*. The camera perspective varied among recordings.

The notational analysis was conducted using (1) the software Windows Media Player (Microsoft® Corporation, USA) to run the video footage and (2) the data file to code the performance variables (shot direction and goalkeeper's action) and the penalty outcome. The shot direction was registered (from 1 to 8) considering the division of the goal into 8 equal sized zones: 4 horizontal directions x 2 vertical directions (see Figure 1).

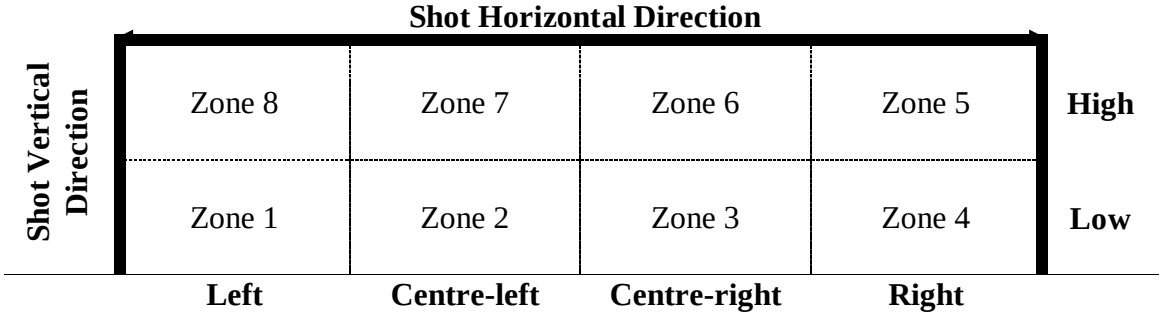

Figure 1. Eight shooting zones defined according to shot horizontal and vertical (4 x 2) directions (adapted from López-Botella and Palao, 2007).

We also decided to follow the qualitative criteria adopted by López-Botella and Palao (2007), and Palao *et al.* (2010) to differentiate shot direction:

(i) In cases the goalkeeper was placed in the middle of the goal, he was used as a reference mark;
(ii) To understand the shot vertical direction the position of the goalkeeper and his arms were analysed (arms high, high zone; arms low, low zone);
(iii) To perceive the shot horizontal direction the marks on the goal, the ball return from the net, the foot position of goalkeeper, the part of the body used to save the ball, and the arms position in the dive (if any) were considered;
(iv) In case of major doubts, we used a ruler in front plans of the video footage to divide the shooting zones at the instant the ball crossed the goal line;
(v) The shots that hit the goalposts/crossbar or missed the target were registered as the nearest shooting zone defined in the goal.

For the variable goalkeeper's action, we defined three categories according to the work of Chiappori *et al.* (2002):

1) Correct side: the goalkeeper dives to the side of the ball shot by the penalty taker;

2) Middle: the goalkeeper stays in the middle of the goal during the penalty kick (including if the goalkeeper gives a lateral step but remains standing);
3) Wrong side: the goalkeeper dives to the opposite side of the ball shot by the penalty taker.

The penalty outcomes were notated in the data file as one of three possible categories (Hughes and Wells, 2002; Jordet *et al.*, 2007):

1) Goal: the ball shot by the penalty taker crosses completely the goal line;
2) Saved: the goalkeeper saves the ball shot by the penalty taker;
3) Missed: the ball shot by the penalty taker hits the goalposts/crossbar or misses the target (i.e., wide shot).
Criteria: (i) if the goalkeeper saves the ball to the goalpost, for instance, only the first action was considered for analysis; (ii) after a save by the goalkeeper or goalpost/crossbar rebound, the subsequent action was not analysed even though it may have ended in goal; (iii) if the referee ordered to repeat the kick, this penalty was not analysed, since only valid shots were coded (López-Botella and Palao, 2007; Palao *et al.*, 2010).

At last, the data file with all sample coded was exported into SPSS Statistics, version 20.0 (IBM® Corp, NY, USA) for statistical treatment.

2.3. Reliability

Reliability was assessed through intra- and inter-observer testing procedures for performance (shot direction, goalkeeper's action) and dependent variables (penalty outcome). The first author (Ob_1) and two previously trained observers (Ob_2 and Ob_3), with more than three years of experience in performance analysis techniques, notated 80 penalty kicks randomly selected from the total sample (≈ 15%). For intra-observer reliability procedures the Ob_1 completed a test-retest protocol with a 12-week period separating both sessions to prevent possible learning effects. The inter-observer reliability was assessed using data notated by all observers in a coding session. Weighted kappa (κ) was calculated to evaluate intra- and inter-observer agreements (Table 3).

Table 3. Intra- and inter-observer reliability for shot direction, goalkeeper's action, and penalty kick outcome (weighted kappa values).

	Intra-observer	Inter-observer		
	Ob_{1test}-$Ob_{1retest}$	Ob_1-Ob_2	Ob_1-Ob_3	Ob_2-Ob_3
Shot Direction	0.967	0.901	0.801	0.833
Goalkeeper's Action	1.000	0.853	0.831	0.975
Penalty Outcome	1.000	1.000	1.000	1.000
Weighted κ_{total}	0.989	0.918	0.877	0.936

The values of intra- and inter-observer reliability suggested an overall very good strength of agreement (Robinson and O'Donoghue, 2007).

2.4. Statistical Analysis

Firstly, contingency tables were used to analyse the descriptive statistics. This analysis revealed that no penalty kick was saved (zero occurrences) when the goalkeeper remained in the middle of the goal or dived to the opposite side of the ball, and in all cases when goalkeepers saved the penalty kick they dived to the correct side. Since the category 'saved' of the response variable Penalty Outcome and the category 'correct side' of the independent variable Goalkeeper's Action fully coincided, we could not include this variable into the next statistical procedure. Secondly, we performed multinomial logistic regression analyses to estimate the probabilities of occurrence of penalty outcome according to different sets of independent variables (factors). These analyses broke the dependent variables down into a series of comparisons between two categories, including the reference category (Field, 2009). The final model, which better fitted the data, included only the main effects of the following factors: Match Status, Match Period, Footedness, Shot Horizontal Direction, and Shot Vertical Direction. A stepwise procedure was conducted to test the interaction terms in the model, but none of them were significant; thus no interactions were added to the final model. The category 'goal' of the dependent variable was chosen as the reference category once it was the most frequent in the sample. The level of statistical significance was set at $p \leq 0.05$.

3. Results

From the 536 analysed penalty kicks, 407 (75.9%) resulted in goal, 101 (18.8%) were saved by the goalkeeper and 28 (5.2%) were missed. The number of goals scored through penalty kicks represents 7.3% of the total number of goals obtained in the sampled matches. The Figure 2 presents the frequencies of penalty outcomes and success rates according to shot direction.

Zone 8 Goal = 43 Saved = 3 Missed = 6 **% Goals = 82.7**	**Zone 7** Goal = 18 Saved = 1 Missed = 4 **% Goals = 78.3**	**Zone 6** Goal = 21 Saved = 3 Missed = 5 **% Goals = 72.4**	**Zone 5** Goal = 26 Saved = 0 Missed = 2 **% Goals = 92.9**
Zone 1 Goal = 149 Saved = 33 Missed = 6 **% Goals = 79.3**	**Zone 2** Goal = 28 Saved = 20 Missed = 0 **% Goals = 58.3**	**Zone 3** Goal = 24 Saved = 12 Missed = 0 **% Goals = 66.7**	**Zone 4** Goal = 98 Saved = 29 Missed = 5 **% Goals = 74.2**

Figure 2. Penalty outcomes (absolute frequencies) and success rates according to shot direction (n = 536).

Penalty takers achieved highest success rates (above 82%) when the shots were directed to zones 5 and 8 (upper corners); the lowest success (below 67%) was registered for low zones in the centre of the goal (zones 2 and 3). The Figure 3 shows how penalty outcomes and success rates varied according to the footedness of penalty takers in each shooting zone. Right-footed players were more effective when they shot to the upper corners of the goal (zone 5: 90% and zone 8: 84.8%) and to zone 6 (83.3%), and less effective when they aimed the shot to zone 2 (54.1%). Curiously, left-footed players

obtained higher success rates when their shots were directed to zones 5 (100%), 7 (100%), and 1 (83.3%). These players were particularly ineffective when the shot aimed the centre-right side (zones 3 and 6) of the goal (22.2% and 54.5%, respectively). Despite directing more shots to left and centre-left zones of the goal (61.3% vs. 38.7%), right-footed players were more successful when they aimed the shot to the opposite side (i.e., centre-right and right zones) of the goal (79.5% vs. 76%). The exact opposite trend was observed for left-footed players: although they aimed more shots to centre-right and right zones of the goal (55.1% vs. 44.9%), the success rates were higher for shots directed to left and centre-left zones (79.2% vs. 62.7%).

Zone 8		**Zone 7**		**Zone 6**		**Zone 5**	
Right-F	Left-F	Right-F	Left-F	Right-F	Left-F	Right-F	Left-F
G = 39	G = 4	G = 17	G = 1	G = 15	G = 6	G = 18	G = 8
S = 2	S = 1	S = 1	S = 0	S = 1	S = 2	S = 0	S = 0
M = 5	M = 1	M = 4	M = 0	M = 2	M = 3	M = 2	M = 0
% = 84.8	**% = 66.7**	**% = 77.3**	**% = 100**	**% = 83.3**	**% = 54.5**	**% = 90.0**	**% = 100**
Zone 1		**Zone 2**		**Zone 3**		**Zone 4**	
Right-F	Left-F	Right-F	Left-F	Right-F	Left-F	Right-F	Left-F
G = 124	G = 25	G = 20	G = 8	G = 22	G = 2	G = 77	G = 21
S = 31	S = 2	S = 17	S = 3	S = 5	S = 7	S = 21	S = 8
M = 3	M = 3	M = 0	M = 0	M = 0	M = 0	M = 3	M = 2
% = 78.5	**% = 83.3**	**% = 54.1**	**% = 72.7**	**% = 81.5**	**% = 22.2**	**% = 76.2**	**% = 67.7**

Figure 3. Absolute frequencies of penalty outcomes (G – Goal; S – Saved; M – Missed) and success rates according to shot direction and penalty takers' footedness (n = 536).

The distribution of penalty kicks outcomes (absolute and relative frequencies) according to situational, individual and performance variables are presented in Table 4.

Table 4. Absolute (and relative: %) frequencies of situational, individual and performance variables according to the penalty outcome.

Variable / Category	Penalty Outcome		
	Goal	Saved	Missed
Competition Phase			
Play-offs	75 (73.5)	23 (22.5)	4 (3.9)
Group stage	248 (77.3)	57 (17.8)	16 (5.0)
Knockout phase	84 (74.3)	21 (18.6)	8 (7.1)
Match Location			
Home	264 (76.5)	63 (18.3)	18 (5.2)
Away	143 (74.9)	38 (19.9)	10 (5.2)
Match Status			
Winning	118 (74.7)	34 (21.5)	6 (3.8)
Drawing	156 (78.8)	29 (14.6)	13 (6.6)
Losing	133 (73.9)	38 (21.1)	9 (5.0)
Match Period			
00:01–30:00	106 (78.5)	25 (18.5)	4 (3.0)
30:01–60:00	125 (71.0)	42 (23.9)	9 (5.1)
60:01–90:00	176 (78.2)	34 (15.1)	15 (6.7)
Footedness			
Right	332 (77.4)	78 (18.2)	19 (4.4)
Left	75 (70.1)	23 (21.5)	9 (8.4)
Position			
Defender	29 (78.4)	5 (13.5)	3 (8.1)
Midfielder	145 (75.1)	38 (19.7)	10 (5.2)
Forward	233 (76.1)	58 (19.0)	15 (4.9)
Age Difference to the Gk			
Younger (< -3.1 years)	164 (77.4)	37 (17.5)	11 (5.2)
Similar age (-3.0 – 3.0 years)	165 (76.0)	41 (18.9)	11 (5.1)
Older (> 3.1 years)	78 (72.9)	23 (21.5)	6 (5.6)
Shot Horizontal Direction			
Left	192 (80.0)	36 (15.0)	12 (5.0)
Centre-left	45 (64.3)	21 (30.0)	4 (5.7)
Centre-right	46 (69.7)	15 (22.7)	5 (7.6)
Right	124 (77.5)	29 (18.1)	7 (4.4)
Shot Vertical Direction			
Low	300 (74.1)	94 (23.2)	11 (2.7)
High	107 (81.7)	7 (5.3)	17 (13.0)
Goalkeeper's Action			
Correct side	169 (59.1)	101 (35.3)	16 (5.6)
Middle	12 (100.0)	0 (0.0)	0 (0.0)
Wrong side	226 (95.0)	0 (0.0)	12 (5.0)

Table 5 displays regression coefficients, Wald statistics, odds ratios, and 95% confidence intervals for odds ratios (i.e., parameter estimates) for each factor included in the best-fitted model estimated through multinomial logistic regression.

Table 5. Parameter estimates of multinomial logistic regression of penalty outcome as a function of situational, individual, and performance factors.

Variables / Categories	*B*	Wald	*p*	OR	95% CI
Saved (reference: Goal)					
Match Status: Winning vs. Losing	-0.040	0.020	0.888	0.961	[0.554; 1.668]
Match Status: Drawing vs. Losing	-0.541	3.409	0.065	0.582	[0.327; 1.034]
Match Period: 00:01–30:00 vs. 60:01–90:00	0.442	2.004	0.157	1.556	[0.844; 2.868]
Match Period: 30:01–60:00 vs. 60:01–90:00	0.715	6.834	0.009	2.045	[1.196; 3.497]
Footedness: Right-footed vs. Left-footed	-0.149	0.275	0.600	0.861	[0.493; 1.505]
Shot Horizontal Direction: Left vs. Right	-0.194	0.468	0.494	0.824	[0.472; 1.436]
Shot Horizontal Dir.: Centre-Left vs. Right	1.005	7.986	0.005	2.731	[1.360; 5.482]
Shot Horizontal Dir.: Centre-Right vs. Right	0.747	3.747	0.053	2.110	[0.991; 4.495]
Shot Vertical Direction: High vs. Low	1.780	17.750	0.000	5.929	[2.590; 13.569]
Missed (reference: Goal)					
Match Status: Winning vs. Losing	-0.243	0.171	0.679	0.792	[0.262; 2.396]
Match Status: Drawing vs. Losing	0.313	0.427	0.514	1.368	[0.534; 3.505]
Match Period: 00:01-30:00 vs. 60:01-90:00	-1.083	3.095	0.079	0.339	[0.101; 1.132]
Match Period: 30:01-60:00 vs. 60:01-90:00	-0.256	0.315	0.575	0.775	[0.317; 1.890]
Footedness: Right-footed vs. Left-footed	-0.725	2.525	0.112	0.484	[0.198; 1.184]
Shot Horizontal Direction: Left vs. Right	0.172	0.112	0.738	1.188	[0.433; 3.261]
Shot Horizontal Dir.: Centre-Left vs. Right	0.272	0.161	0.688	1.312	[0.348; 4.955]
Shot Horizontal Dir.: Centre-Right vs. Right	0.225	0.119	0.730	1.252	[0.350; 4.478]
Shot Vertical Direction: High vs. Low	-1.438	11.755	0.001	0.237	[0.104; 0.540]

Note: *B:* Regression Coefficient; *p*: p-value; OR: Odds Ratio; CI: Confidence Interval.
Pseudo R^2 = 0.123 (Cox & Snell), 0.165 (Nagelkerke), 0.096 (McFadden). Model $\chi^2(18) = 70.102$.

The Pearson and Deviance values ($p = 0.498$, $p = 0.933$) indicated that the predicted values were not significantly different from the observed values; that is, the model has a good fit. Besides, the pseudo R^2 values (Cox & Snell, Nagelkerke, and McFadden) showed the model presented a small effect size. The Match Period, and Shot Horizontal and Vertical Directions significantly influenced the penalty outcome ($p < 0.05$), while the effects of Match Status and Footedness have not been confirmed. The effect of the situational variable Match Period was identified comparing the second (30:01–60:00) and the third match periods (60:01–90:00). Hence, the odds of the penalty kick being saved by the goalkeeper instead of scored were 104.5% higher in the middle of matches comparing to the final half-hour. Regarding the performance factors, when penalty takers shot to the centre-left side (zones 2 and 7) compared to the right side of the goal (zones 4 and 5), the probability of the penalty kick being saved (instead of scored) increased by 173.1%. When penalty takers directed the shot to the centre-right side (zones 3 and 6), the odds of the penalty kick being saved also increased, however, the result was just a marginal trend toward significance ($p = 0.053$). Furthermore, the shot vertical direction also significantly predicted whether penalty takers missed the target or scored ($p = 0.001$). Penalty takers were 76.3% less likely to miss the target when they directed the shot to low zones of the goal, than when the shot aimed the high zones. Also, the probability of the penalty kick being saved by the goalkeeper increased by 492.9% when the player directed the shot to the low zones of the goal (1, 2, 3 and 4) relatively to shots directed to the high zones (5, 6, 7 and 8). The goalkeepers also have a word to say about the penalty outcome. The results of contingency tables, presented in Table 4, pointed out that when goalkeepers dived to the correct side of the ball shot by the penalty taker, the probability of saving the penalty kick were tremendously higher

than when they remained in the middle of the goal or dived to the opposite side of the ball.

4. Discussion

The purpose of this study was to investigate main and interaction effects of situational, individual, and performance factors on penalty kick outcome in UEFA Champions and Europa leagues. Considering our match sample, 7.3% of the goals were achieved through penalty kicks; this number is similar to the one obtained by Gelade (2014) in previous research (7.7%). Although few goals are scored from penalty kicks in soccer, our data indicated that, on average, a penalty kick is awarded by the referee in 1 out of 4 matches. The percentages obtained for each penalty outcome (Goal: 75.9%; Saved: 18.8%; Missed: 5.2%) are within the range of values reported by previous research in top leagues and championships worldwide (e.g., Bar-Eli *et al.*, 2007; López-Botella and Palao, 2007; White and O'Donoghue, 2013). The current investigation found that, at least, 7 out of 10 penalty kicks awarded during UEFA international club matches resulted in goal (Palao *et al.*, 2010). The penalty kick can play a decisive role in some tight matches and may affect the final classification of an elite club competition. Thus, these set pieces should be systematically practiced by players usually involved in this dynamic dyadic system: penalty taker and goalkeeper (McGarry and Franks, 2000; Jordet *et al.*, 2007; Lopes *et al.*, 2014a).

In the perspective of Gelade (2014), the penalty kick provides data amenable to mathematical modeling. So, by including situational, individual and performance factors in a multinomial logistic regression analysis, we have estimated a model to predict the likelihood of occurrence of penalty kick outcome. According to the model parameters, none of the individual factors influenced the penalty outcome. This fact does not support the reasoning that players with more offensive roles and goal-scoring skill (i.e., forwards) are more successful from the penalty mark (Jordet *et al.*, 2007). Besides, our results showed that defenders were slightly more effective than forwards or midfielders. Although right-footed players were 7.3% more effective in shooting from the penalty mark than their left-footed counterparts, the footedness did not predict the penalty outcome, which corroborate previous findings (López-Botella and Palao, 2007; Palao *et al.*, 2010; White and O'Donoghue). The age difference of penalty takers relatively to goalkeepers did not enter in the regression model either. Our results did not support the reasoning of Jordet *et al.* (2007) and Lopes *et al.* (2012), who suggested that perhaps younger players benefits from being less disposed to stress or have fewer experiences, their own or from observation of others, of failure in penalty kicks.

From all situational variables, only the factor Match Period significantly predicted if the penalty kick was saved by the goalkeeper or scored. Our results showed that, in first and final half-hours of match-play, the penalty takers were more effective than in the middle of matches. Unlike the findings of Chiappori *et al.* (2002), we did not verify a decline in the success rate toward the end of the match. Since it is in the final half-hour that most of the matches are decided, we suppose that the previously suggested increase of psychological pressure (Jordet *et al.*, 2007) may have enhanced the focus on the task and the shot effectiveness of specialist penalty takers. Therefore, coping with stress in

high-pressure contexts might be a crucial aspect to avoid suboptimal penalty kick performance in UEFA club competitions (Jordet *et al.*, 2007; Jordet, 2009). The lower success rate found in the middle of matches reflects a decrease in the shooting performance in the 15-min periods preceding and following the half-time break. During the first half, this may be due to temporary decreases in performance after periods of high-intensity exercise (Mohr *et al.*, 2003); however, the physiological, perceptual, and/or psychological mechanisms underlying such detriment in the performance of penalty takers need of further research. Furthermore, there is a plethora of studies demonstrating that passive half-time practices impair both physical and cognitive performances in the initial stages of the second half of team-sports competition (for a review, see Russell *et al.*, 2015). The reported physiological and cognitive changes (e.g., lower muscle and core temperatures, acid-base balance, mental relaxation, etc.) may negatively influence neuromuscular coordination and the shooting skills needed for successfully perform in penalty kicks (Masuda *et al.*, 2005; Russell *et al.*, 2015).

The factors Shot Horizontal and Vertical Directions also predicted if the penalty kick was saved by the goalkeeper or scored. Concerning the Shot Horizontal Direction, both right- and left-footed players obtained higher success rates when shots were directed to the left side of the goal (zones 1 and 8; see Figure 3). Our findings do not totally support the so-called 'natural' side of penalty takers (Chiappori *et al.*, 2002; White and O'Donoghue, 2013). Although right- and left-footed players shot more times to their 'natural' sides (i.e., left zones for right-footed and right zones for left-footed players), only right-footed players achieved high effectiveness to their 'natural' side. Their left-footed counterparts achieved higher success rates when the shots aimed their 'non-natural' side. Our findings also differ from those of Bar-Eli and Azar (2009), who claimed that shooting to the centre of the goal seems to be the best strategy for penalty takers. In fact, the odds of a penalty kick being saved by the goalkeeper significantly increased when the player directed the shot to the centre-left side of the goal (zones 2 and 7). According to Fariña *et al.* (2013), the centre zones are not safe for shots unless the goalkeeper starts to move too early. The chances of a penalty kick being saved by the goalkeeper substantially increased when the penalty taker directed the shot to the low zones of the goal and when the goalkeeper dived to the correct side of the ball (López-Botella and Palao, 2007; Bar-Eli and Azar, 2009; White and O'Donoghue, 2013). Despite the penalty taker being in advantage during the penalty kick, our data confirmed the importance of goalkeeper's action for the final outcome (Fariña *et al.*, 2013). Bar-Eli *et al.* (2007) found a match between shot and dive directions in 43% of their penalty kicks' sample. The match found in our sample was 10.4% greater, which indicates the goalkeepers in UEFA club competitions were more accurate in perceiving/anticipating the side of the ball shot by penalty takers. These results rule out the hypothesis that goalkeepers choose randomly a side to dive, suggesting their dives were, at least to some extent, based on detected information (Dicks *et al.*, 2010; Lopes *et al.*, 2014b). Interestingly, the goalkeepers exhibited a bias towards action (Bar-Eli *et al.*, 2007), since they only remained in the middle of the goal in 2.2% of penalty kicks.

Finally, we also verified the Shot Vertical Direction predicted whether the penalty taker missed the target or scored; that is, the 'miss factor' is really important in the high zones of the goal (Hughes and Wells, 2002; Palao *et al.*, 2010; White and O'Donoghue, 2013). Nevertheless, we noted the probability of missing the penalty kick when the shot aimed

the high zones was lower than the risk of being saved by the goalkeeper when the shot aimed the low zones of the goal. Based on the current findings and those from previous research, we recommend that penalty takers should direct the shot to the high zones of the goal, particularly to the upper corners, which are practicably unreachable for the goalkeepers (López-Botella and Palao, 2007; Navarro *et al.*, 2013; White and O'Donoghue, 2013). In case of doubt, and irrespective of footedness, directing the shot to the left side of the goal seems to be a fruitful strategy. However, since participants know a great deal about the past history of behaviour on the part of opponents (Chiappori *et al.*, 2002), we advice penalty takers to be as unpredictable as possible in order to enhance the shooting performance (Noël *et al.*, 2015). For goalkeepers, diving to the correct side of the ball is paramount to increase the odds of saving the penalty kick. Therefore, they should wait longer before initiating a response in order to correctly perceive the ball trajectory (Savelsbergh *et al.*, 2002, 2005; Lopes *et al.*, 2014b). Coaches should be encouraged to include the systematic practice of penalty kicks in their training programs. Designing the penalty kick practice needs to be innovative in order to recreate the levels of anxiety, distraction and perceptions of control raised by such high-pressure situations (Jordet *et al.*, 2007; Wood *et al.*, 2015).

The major strength of this exploratory study is the high ecological validity of evaluating elite soccer players (penalty takers and goalkeepers) in the most prestigious international club competitions in Europe. However, the observational design used in the study has some limitations because establishes causal relationships between variables, which do not always reflect the complexity of the interactions between different factors that influence performance. Despite most of our results seem to be logical, the reasoning behind the explanation of data might seem somehow speculative (Jordet *et al.*, 2009). So, the generalization of the present findings should be carefully considered in future studies involving different samples of penalty kicks.

5. Conclusion

This study provided new insights about the effects of situational, individual and performance factors on penalty kick outcome in UEFA club competitions. Although the factors associated to the performances of penalty taker and goalkeeper (i.e., Shot Horizontal and Vertical Directions, and Goalkeeper's Action) were the most decisive for determining the penalty outcome, the situational factor Match Period also significantly influenced the success of penalty kicks. In particular, penalty takers were less effective in the middle of match-play. Knowing the most prominent factors for penalty takers and goalkeepers achieving success in penalty kicks enables coaches not only to optimize the systematic practice of these set pieces in training programs, but also to select the right players to succeed in penalty kicks, taking into account specific match-play contexts.

6. References

Bar-Eli, M. and Azar, O.H. (2009), Penalty kicks in soccer: An empirical analysis of shooting strategies and goalkeepers' preferences. **Soccer & Society**, 10(9), 183-191.

Bar-Eli, M., Azar, O.H., Ritov, I., Keidar-Levin, Y. and Schein, G. (2007), Action bias among elite soccer goalkeepers: The case of penalty kicks. **Journal of Economic Psychology**, 28(5), 606-621.

Chiappori, P.-A., Levitt, S. and Groseclose, T. (2002), Testing mixed-strategy equilibria when players are heterogeneous: The case of penalty kicks in soccer. **The American Economic Review**, 92(4), 1138-1151.

Collet, C. (2013), The possession game? A comparative analysis of ball retention and team success in European and international football, 2007–2010. **Journal of Sports Sciences**, 31(2), 123-136.

Cox, D.R. and Snell, D.J. (1989), **The analysis of binary data (2nd Ed.)**. London: Chapman & Hall.

Dicks, M., Button, C. and Davids, K. (2010), Availability of advance visual information constrains association-football goalkeeping performance during penalty kicks. **Perception**, 39(8), 1111-1124.

Fariña, R.A., Fábrica, G., Tambusso, P.S. and Alonso, R. (2013), Taking the goalkeeper's side in association football penalty kicks. **International Journal of Performance Analysis in Sport**, 13(1), 96-109.

Field, A. (2009), **Discovering statistics using SPSS (3rd Ed.)**. London: SAGE Publications Ltd.

Gelade, G. (2014), Evaluating the ability of goalkeepers in English Premier League football. **Journal of Quantitative Analysis in Sports**, 10(2), 279-286.

Hughes, M. and Wells, J. (2002), Analysis of penalties taken in shoot-outs. **International Journal of Performance Analysis in Sport**, 2(1), 55-72.

Jordet, G. (2009), Why do English players fail in soccer penalty shootouts? A study of team status, self regulation, and choking under pressure. **Journal of Sports Sciences**, 27(2), 97-106.

Jordet, G., Hartman, E. and Sigmundstad, E. (2009), Temporal links to performing under pressure in international soccer penalty shootouts. **Psychology of Sport and Exercise**, 10, 621-627.

Jordet, G., Hartman, E., Visscher, C. and Lemmink, K. (2007), Kicks from the penalty mark in soccer: The roles of stress, skill, and fatigue for kick outcomes. **Journal of Sports Sciences**, 25(2), 121-129.

Lopes, J.E., Araújo, D. and Davids, K. (2014a), Investigative trends in understanding penalty-kick performance in association football: An ecological dynamics perspective. **Sports Medicine**, 44(1), 1-7.

Lopes, J.E., Araújo, D., Duarte, R., Davids, K. and Fernandes, O. (2012), Instructional constraints on movement and performance of players in the penalty kick. **International Journal of Performance Analysis in Sport**, 12, 311-345.

Lopes, J.E., Jacobs, D.M., Travieso, D. and Araújo, D. (2014b), Predicting the lateral direction of deceptive and non-deceptive penalty kicks in football from the kinematics of the kicker. **Human Movement Science**, 36, 199-216.

López-Botella, M. and Palao, J.M. (2007), Relationship between laterality of foot strike and shot zone on penalty efficacy in specialist penalty takers. **International Journal of Performance Analysis in Sport**, 7(3), 26-36.

Masuda, K., Kikuhara, K., Demura, S. and Yamanaka, K. (2005), Relationship between muscle strength in various isokinetic movements and kick performance among soccer players. **Journal of Sports Medicine and Physical Fitness**, 45, 44-52.

McFadden, D. (1974), Conditional logit analysis of qualitative choice behavior. In Zarembka, P. (Ed.), **Frontiers in Econometrics** (pp. 105-142). New York: Academic Press.

McGarry, T. and Franks, I.M. (2000), On winning the penalty shoot-out in soccer. **Journal of Sports Sciences**, 18, 401-409.

Mohr, M., Krustrup, P. and Bangsbo, J. (2003), Match performance of high-standard soccer players with special reference to development of fatigue. **Journal of Sports Sciences**, 21, 519-528.

Morya, E., Ranvaud, R. and Pinheiro, W.M. (2003), Dynamics of visual feedback in a laboratory simulation of a penalty kick. **Journal of Sports Sciences**, 21, 87-95.

Nagelkerke, N.J.D. (1991), A note on a general definition of the coefficient of determination. **Biometrika**, 78, 691-692.

Navarro, M., van der Kamp, J., Ranvaud, R. and Savelsbergh, G.J.P. (2013), The mere presence of a goalkeeper affects the accuracy of penalty kicks. **Journal of Sports Sciences**, 31(9), 921-929.

Noël, B., Furley, P., van der Kamp, J., Dicks, M. and Memmert, D. (2015), The development of a method for identifying penalty kick strategies in association football. **Journal of Sports Sciences**, 33(1), 1-10.

Palao, J.M., López-Montero, M. and López-Botella, M. (2010), Relationship between efficacy, laterality of foot strike, and shot zone of the penalty in relation to competition level in soccer. **International Journal of Sport Science**, 6(19), 154-165.

Robinson, G. and O'Donoghue, P. (2007), A weighted kappa statistic for reliability testing in performance analysis in sport. **International Journal of Performance Analysis in Sport**, 7(1), 12-19.

Russell, M., West, D.J., Harper, L.D., Cook, C.J. and Kilduff, L.P. (2015), Half-time strategies to enhance second-half performance in team-sports players: A review and recommendations. **Sports Medicine**, 45(3), 353-364.

Savelsbergh, G.J.P., van der Kamp, J., Williams, A.M. and Ward, P. (2005), Anticipation and visual search behaviour in expert soccer goalkeepers. **Ergonomics**, 48(11-14), 1686-1697.

Savelsbergh, G.J.P., Williams, A.M., van der Kamp, J. and Ward, P. (2002), Visual search, anticipation and expertise in soccer goalkeepers. **Journal of Sports Sciences**, 20, 279-287.

Weigelt, M. and Memmert, D. (2012), Goal-side selection in soccer penalty kicking when viewing natural scenes. **Frontiers in Psychology**, 1-7.

White, S. and O'Donoghue, P. (2013), Factors influencing penalty kick success in soccer. In Nunome, H., Drust, B. and Dawson, B. (Eds.), **Science and football VII: The proceedings of the seventh world congress on science and football** (pp. 237-242). London: Routledge, Taylor & Francis Group.

Willekens, F. (2013), Chronological objects in demographic research. **Demographic research**, 28(23), 649-680.

Wood, G., Jordet, G. and Wilson, M. R. (2015), On winning the "lottery": Psychological preparation for football penalty shoot-outs. **Journal of Sports Sciences**, 33(17), 1758-1765.