Investigating the Inter-League and Inter-Nation Variations of Key Determinants for Penalty Success across European Football

Mikael Jamil, Perry Littman and Marco Beato

School of Health and Sports Sciences, University of Suffolk, Ipswich, United Kingdom

Corresponding author: Mikael Jamil, School of Health and Sports Sciences, University of Suffolk, Ipswich, United Kingdom, email: m.jamil2@uos.ac.uk

This is an Accepted Manuscript of an article published by Taylor & Francis in International Journal of Performance Analysis in Sport on 26/8/20, available online: https://www.tandfonline.com/doi/full/10.1080/24748668.2020.1794720

Investigating Inter-League and Inter-Nation Variations of Key Determinants for Penalty Success across European Football

Abstract

The aim of this study was to investigate the inter-league and inter-nation variations of key performance, situational and individual variables on penalty success across four elite European football leagues. A sample of 1,716 penalty kicks taken in four consecutive seasons (2015/16 - 2018/19) were analysed via a series of bootstrapped regressions. Results revealed that penalty success in each country depends upon; the length of the run up, the direction of the strike, the type of strike, which foot the penalty is struck with, match status, time periods and venue, but to varying extents in each league. Penalty takers in the English Premier League aimed centrally (p=0.003) whereas penalty kicks were aimed towards the bottom corners in the Spanish La Liga (p=0.009), German Bundesliga (p=0.004) and Italian Serie A (p=0.004). Inter-nation variations were also discovered between classes of variables associated with the length of the run-up, the type of strike, which foot the penalty is struck with, match status, time periods and venue. The authors conclude that penalty takers should pay special attention to the inter-league variations

discovered in this study in order to further inform their penalty strategies and enhance their levels of unpredictability, ultimately increasing their penalty proficiency.

Keywords: soccer; set pieces; spot-kick; performance analysis; situational variables; individual variables

Introduction

To win a football match a team must score more goals than the opposing team, which explains why the act of goal scoring has received considerable attention in performance analysis research (Pulling, 2015; Shafizadeh et al., 2013). Previous research has revealed that approximately one third of goals within elite football are scored either directly or indirectly from a set play (Pulling, 2015; Yiannakos & Armatas, 2006). Consequently, recent years have seen an increase in research examining the effectiveness of set plays such as free kicks, corner kicks, penalty kicks, and throw-ins (Almeida et al., 2016; Cerrah et al., 2016; De Baranda & Lopez-Riquelme, 2012). As stated by Sarmento et al. (2018), a major reason for the enhanced interest in penalty kicks is due to the fact that they can often lead to match winning situations (Bar-Eli & Azar, 2009).

Although there are some psychological variables that can influence penalty kicks (Memmert et al., 2013; Navia et al., 2019) from a purely technical perspective, Bar-Eli and Azar (2009) argued that a penalty kick represents a fairly easy opportunity to score as the ball is placed centrally, 10.97 metres (12 yards) away from the goal which is itself 7.32 metres wide (8 yards) and 2.44 metres high (8 feet). Recent research focussing on the technical dynamics of penalty kicks has identified several key variables that can enhance the overall chances of

scoring a penalty kick. In the main, these variables consist of the direction the ball travels in (or is aimed towards) by the penalty taker when striking a penalty kick (Bar-Eli & Azar, 2009; Fariña et al., 2013), run-up fluency and striking techniques (Lees & Owens, 2011; Timmis et al., 2014), several situational variables such as venue, match status and game period (Almeida et al., 2016; Armatas et al., 2013) and individual variables such as the penalty takers preferred foot (Baumann et al., 2011; Dohmen, 2008; Dohmen & Sonnabend, 2018; Lees & Owens, 2011).

While this previous research has identified some commonalities such as, home teams being awarded a greater number of penalty kicks (Armatas et al., 2013; Sutter & Kocher, 2004) and left footed penalty takers enjoying more success (Baumann et al., 2011; Dohmen, 2008; Dohmen & Sonnabend, 2018), there have also been some contradictory findings. For example, some studies have discovered that footedness had no significant impact upon penalty success (Almeida et al., 2016; López-Botella & Palao, 2007). Furthermore, there are some inconsistencies with regards to where penalty takers should aim as Bar-Eli & Azar (2009), recommended aiming centrally, whereas Almeida et al. (2016), suggested aiming slightly left of centre and López-Botella & Palao, (2007) concluded that penalty takers should aim towards the higher zones of the goal. In addition, there have been some conflicting findings relating to penalty success in different nations and competitions. For example, Hughes & Wells (2002), suggested German penalty takers were more efficient than their international counterparts, whereas Brinkschulte et al. (2020), discovered no significant differences between penalty takers from different nations.

A drawback of much of this previous research on penalty kicks is that they have overlooked how the dynamics of taking a successful penalty can vary from league to league or nation to nation. Football is practiced differently in every country (Jamil et al., 2020; Mitrotasios et al., 2019; Sarmento et al., 2013) and the effects of these peculiarities that

characterise each nation have not been examined with regards to penalty taking or many other aspects of match analysis that are likely to exhibit inter-country variation (Mackenzie & Cushion, 2013). A further limitation of much of this previous research on penalty kicks is that the focus has tended to be on penalty kicks taken in either one league across many seasons or information has been collated from several international knock-out football tournaments. In addition, some of these studies have focussed on penalty shoot-outs rather than penalties taken during a traditional 90-minute match and or relied on penalty simulations. As stated by Jamil (2019), it is preferable to assess repeated trials such as league fixtures when assessing performance in football as these are more likely to reveal genuine team and player efforts as opposed to traditional knock-out competitions where the element of chance has a significant bearing on success.

Taking the above into consideration, the aims of this study were to assess the impact of the key variables identified by the aforementioned literature upon penalty success across several European football leagues in order to determine the level of inter-league and inter-nation variations between them. It is the authors understanding that the results of this study will inform researchers, sports scientists, coaches and professional players performing in each of the subject nations what can be specifically done to enhance penalty success (from the penalty takers perspective) and subsequently decrease penalty success (from the goalkeepers perspective) across European football.

Methods

Experimental Design

This retrospective study evaluated the influence of several performance, situational and individual variables on penalty success including; the length of run up (Noël et al., 2015); the direction of the strike (Bar-Eli & Azar, 2009; Fariña et al., 2013); the type of shot (Lees & Owens, 2011; Timmis et al., 2014); the takers' preferred foot (Baumann et al., 2011; Dohmen,

2008); match status (Almeida et al., 2016); time period (Almeida et al., 2016) and venue (Armatas et al., 2013; Dohmen, 2008). Definitions for each of these variables were outlined prior to data collection in order to ensure interpretation of events was consistent amongst all parties involved in the data procurement process (table 1). For the variable "direction of the strike" the goal was broken up into 9 equal sized zones (figure 1)[1], as previous studies examining penalty kicks have also broken up the goal area into several zones to suit the needs of their studies (Bar-Eli & Azar, 2009; Fariña et al., 2013).

*****Insert Table 1 here*****

*****Insert Figure 1 here*****

Data

The authors collected data on 1,716 penalty kicks that had been taken during 312 traditional 90 minute league matches. Each penalty analysed was taken within four consecutive seasons ranging from the start of the 2015/2016 season through to the end of the 2018/2019 season. In the case a penalty had to be retaken, only data collected on the retaken penalty was included in this study. Penalty kicks taken in the following leagues, the English Premier League (EPL), the Spanish La Liga (SLL), the German Bundesliga (GB) and the Italian Serie A (ISA) were chosen for this study. Out of the 1,716 penalty kicks analysed in this study, 1,304 penalty kicks were scored and 412 penalty kicks were either missed or saved by the goalkeeper resulting in an overall success rate of 76% across the four European leagues analysed. Data for the 412 missed or saved penalties was not collected for the independent variables as this would have led to some gaps in the data (for instance, a penalty missed by striking the ball wide would not allow us to record data for the direction of the strike independent variable).

Reliability

[1] In cases where the ball was struck in between two zones, the direction of the strike was classified according to the observer's interpretation.

Reliability testing was conducted akin to Jamil (2019) and thus consisted of two phases:

Phase 1 – All penalty kicks were downloaded from Wyscout SpA (Chiavari, Italy) and Sportscode v10 (Hudl, USA) was used to code information on each variable for each of the 1,304 penalty kicks that were scored (C1). Intra-observer reliability tests were then conducted by recoding 306 randomly selected penalty kicks 6 weeks later (C2).

Phase 2 – Inter-observer reliability was then conducted a further 2 weeks after phase 1 reliability was complete (thus 8 weeks after C1 and 2 weeks after C2) by an independent operator who was observing penalty kicks from the sample for the first time. For this phase, 306 penalty kicks were again selected with 20% (61 penalty kicks) randomly selected out of the 306 penalty kicks observed during C2 and a further 245 penalty kicks randomly selected of the remaining 998 penalty kicks observed during C1. Sample sizes of 306 for the test-retest phases detailed above were determined by Slovin's formula (equation 1 below) with a 5% error as used by Kipsaina et al. (2017).

The weighted kappa statistic was calculated as a means to test the inter-observer reliability of the data collection procedure as recommended by Jamil (2019) and Liu et al. (2013). The interpretation of kappa values obtained was as follows: < 0 less than chance agreement; 0.01-0.20 poor agreement; 0.21-0.40 fair agreement; 0.41-0.60 moderate agreement; 0.61-0.80 good agreement; 0.81-0.99 almost perfect agreement (Jamil, 2019; Liu et al., 2013; Viera & Garrett, 2005). The kappa value for the intra-observer reliability (C2) was 0.9956 indicating a high level of agreement (almost perfect) between the (C1) and (C2) coding attempts by observer 1. Out of a total of 1,699[2] events recorded in this sample of 306 penalty kicks, there were 1,692 agreements (only 7 discrepancies). The kappa value for inter-observer reliability was 0.9918 revealing a very high degree of agreement between observer 1 and observer 2. Out of a total of 1,573[3] events recorded in this sample of 306 penalty kicks, there

[2] Sum of all data events recorded for the 306 penalty kicks assessed during intra-observer reliability
[3] Sum of all data events recorded for the 306 penalty kicks assessed during inter-operator reliability

were 1,561 agreements (only 12 discrepancies). The reliability results revealed consistency and accuracy in the recording of the number of penalty kick events between observer 1 and observer 2. Table 5 presents the kappa statistics for both intra-observer and inter-observer reliability for all independent variables.

$$n = \frac{N}{1 + Ne^2}$$

(Equation 1)

*****Insert Table 5 here*****

Statistical Analysis

Several assumption tests for Ordinary Least Squares regressions were conducted such as the Breusch-Pagan/Cook-Weisberg test for heteroskedasticity, variance inflation factors (VIF) tests for multi-collinearity and Shapiro-Wilk tests to ascertain the normality of residual errors and violations of these assumptions were detected across all leagues. Consequently, a series of bootstrapped multiple regressions were run in order to investigate which factors influence penalty success rates (equation 2). All testing was conducted on StataSE 12.0 (StataCorp. 2011. *Stata Statistical Software: Release 12*. College Station, TX: StataCorp LP). Two thousand repetitions were selected with bias corrected and accelerated (BCa) 95% confidence intervals (Efron & Tibshirani, 1993; Jamil, 2019). Significance was reported as $p \leq 0.05$.

$$Y_{1jt} = \beta_0 + \beta_1 Z_1 + \beta_2 Z_2 + \ldots\ldots \beta_n Z_n + u_i$$

(Equation 2)

In equation 2, the dependent variable (Y_1) is penalty success rate for team *j* at time *t*. Penalty success rates were expressed as a percentage (calculated as total penalty kicks scored/total penalties taken, then multiplied by 100) resulting in 80 observations for the EPL, 80 observations for the SLL, 72 observations for the GB and 80 observations for the ISA. The explanatory (Z) variables in equation 2 above consisted of several classes of variables relating

to either: the direction of the strike; the type of shot; venue; match status; time period; the length of the run up and which foot the ball was struck with. Cohen's f^2 (Cohen, 1988) global effects sizes (equation 3) and local effect sizes (equation 4) were calculated following multiple regression models (Selya et al., 2012). According to Cohen's (1988) guidelines, $f^2 \geq 0.02$, $f^2 \geq 0.15$ and $f^2 \geq 0.35$, represent *small*, *medium* and *large* effects sizes respectively.

$$f^2 = \frac{R^2}{1 - R^2}$$

(Equation 3)

$$f^2 = \frac{R^2AB - R^2A}{1 - R^2AB}$$

(Equation 4)

Results

Figure 2 reveals the cumulative penalty success rates for each European league in each season analysed in this study. Tables 2, 3 and 4 revealed much inter-league and inter-nation variations of key determinants of penalty success in each of the four European leagues analysed in this study.

*****Insert Figure 2 here*****
*****Insert Table 2 here*****
*****Insert Table 3 here*****
*****Insert Table 4 here*****
*****Insert Table 5 here*****

English Premier League

Results revealed that a medium run up length of between 2-5 steps ($p = 0.046$) and long run-ups of 6+ steps ($p = 0.034$) both positively impacted penalty success, but not short run-ups of less than 2 steps. Location 5 (middle centre) had a significant positive impact upon penalty success ($p = 0.003$), but all other locations were not significant. Only a losing match status had a positive significant impact on penalty success ($p = 0.030$). A placement side-foot striking technique was also revealed to have a significant positive impact on penalty success ($p =$

0.036). Finally, only penalty kicks taken with the right foot had a significant positive impact on penalty success ($p = 0.018$). Neither venue nor time period had any impact on penalty success as both of these variables were revealed to be non-significant.

Spanish La Liga

Results revealed that a medium run up length of between 2-5 steps ($p < 0.001$) and long run-ups of 6+ steps ($p < 0.001$) had a significant positive impact upon penalty success. Location 1 (bottom right, $p = 0.009$) and location 3 (bottom left, $p = 0.048$) had a significant positive impact upon penalty success whereas all other locations were not significant. Both the drawing ($p < 0.001$) and losing ($p = 0.019$) match states had a significant positive impact upon penalty success. Time period results revealed that penalty kicks taken just before half-time (HT) (30 minutes - HT, $p = 0.008$), just after HT (45 minutes to 60, $p < 0.001$) and just before full-time (FT) (75 minutes to FT, $p = 0.008$) had a significant positive impact upon penalty success. Both a placement side-foot type of strike ($p = 0.001$) and an instep power striking technique ($p = 0.001$) were revealed to have a significant positive impact on penalty success. Penalty kicks won at home ($p < 0.001$) and away ($p = 0.003$) both had a significant positive impact upon penalty success, but unstandardised coefficient sizes revealed home penalty kicks had a greater positive impact. Finally, both penalty kicks taken with the right foot ($p < 0.001$) and the left foot ($p = 0.001$) were revealed to have a significant positive impact upon penalty success, but unstandardised coefficient sizes revealed the left foot had a greater positive impact.

German Bundesliga

Results revealed that a medium run up length of between 2-5 steps ($p < 0.001$) and long run-ups of 6+ steps ($p = 0.003$) both had a significant and positively impact on penalty success. Location 2 (bottom centre, $p = 0.001$), location 3 (bottom left, $p = 0.004$) and location 6 (middle right, $p = 0.009$) all had a significant positive impact upon penalty success. All three match states had a significant positive impact upon penalty success rates (drawing, $p = 0.021$;

winning, $p < 0.001$; losing, $p = 0.001$), but winning and losing had a much greater positive impact as revealed by the unstandardised coefficient sizes. Penalty kicks taken just before FT (75 minutes to FT, $p < 0.001$) had a significant positive impact upon penalty success. Both a placement side-foot type of strike ($p = 0.015$) and an instep power striking technique ($p = 0.001$) were revealed to have a significant positive impact on penalty success. Penalty kicks won at home ($p = 0.001$) and away ($p = 0.011$) both had a significant positive impact upon penalty success, but unstandardised coefficient sizes revealed away penalty kicks had a greater positive impact. Finally, both penalty kicks taken with the right foot ($p < 0.001$) and the left foot ($p = 0.007$) were revealed to have a significant positive impact upon penalty success, but unstandardised coefficient sizes reveal the right foot had a greater impact.

Italian Serie A

Results revealed that only a long run-up of 6+ steps ($p < 0.001$) had a significant and positive impact on penalty success. Location 1 (bottom right, $p = 0.004$), location 3 (bottom left, $p = 0.049$) and location 8 (top centre, $p = 0.046$) all had a significant positive impact upon penalty success whereas all other locations were not significant. Only the drawing ($p = 0.001$) and losing ($p = 0.027$) match states had a significant positive impact upon penalty success rates. Penalty kicks taken just before HT (30 minutes to HT, $p = 0.007$) or penalty kicks taken just before FT (75 minutes to FT, $p = 0.022$) had a significant positive impact upon penalty success. Both a placement side-foot type of strike ($p = 0.005$) and an instep power striking technique ($p = 0.002$) were revealed to have a significant positive impact on penalty success. Only penalty kicks won at home ($p = 0.001$) had a significant positive impact upon penalty success. Finally, both penalty kicks taken with the right foot ($p < 0.001$) and the left foot ($p = 0.005$) were revealed to have a significant positive impact upon penalty success, but unstandardised coefficient sizes reveal that the right foot had a greater positive impact.

Global Effect Sizes

Table 2 presents the global effect sizes of each regression conducted and the independent variables; run-up length, match status, time period, type of strike, venue and preferred foot each had a *small* effect upon penalty success in the EPL, but a *medium* effect in the ISA. The variable, direction of the strike, had a *medium* global effect in both the EPL and the ISA.

Large global effect sizes were only discovered in the SLL and the GB for the variables; direction of the strike, match status and time period. The independent variables; run-up length, type of strike, venue and preferred foot each had a *medium* effect upon penalty success in both the SLL and GB.

Discussion

The aim of this study was to investigate the inter-league and inter-nation variations of key performance, situational and individual variables on penalty success rates across four elite European football leagues (EPL, SLL, GB, ISA). The findings proved that there are many different ways to score a penalty kick and methods of success vary from country-to-country and league-to-league. The length of run-ups, direction of the strike, the type of shot and the penalty takers preferred striking foot were all revealed to significantly and positively impact penalty success, to varying extents, in all four leagues and nations. Situational variables such as time period, match status and venue were also found to have a significant positive impact upon penalty success in each of the four leagues analysed, again to varying extents.

The results of this study therefore lend support to the arguments made by Gai et al. (2018), Mitrotasios et al. (2019) and Sarmento et al. (2013), who emphasised that football is played differently in each nation due to various reasons such as differences in the technical skill levels of players, tactics, physical factors, the quality of coaching, individual player development as well as historical, social and cultural aspects of each country, the influence of which vary from nation to nation. Penalty takers in the EPL and GB favoured a medium run-

up between 2-5 steps whereas penalty takers in the SLL and ISA favoured a long run-up of 6 steps or more. These results conform to those discovered by Hughes and Wells (2002), who discovered that run-ups of 4,5 and 6 paces were the most productive with regards to scoring penalty kicks.

Lees and Owens (2011) suggested that the side-foot placement technique favours accuracy over ball speed, whereas the instep power technique favours ball speed over accuracy. Penalty takers in the EPL and ISA preferred a side-foot placement technique suggesting accuracy is considered more important than power (although both were significant in the ISA). In comparison, the instep power technique was preferred by the penalty takers in the SLL and GB, suggesting these penalty takers emphasise ball speed over accuracy. The latter technique could be informed by the fact goalkeepers (GK) have roughly 0.25 seconds to respond once the kick has been taken (Dohmen, 2008); therefore if penalty takers place greater emphasis on ball speed, then in theory the opposing GK has less time to react.

A player's preferred foot impacted penalty success in all leagues, however in the EPL only right footed penalty takers had a significant impact upon penalty success, whereas both feet had a significant impact in the SLL, GB and ISA. Right footed penalty takers were more successful in the EPL, GB and ISA, whereas left footed takers enjoyed more success in the SLL. These results contradict those obtained by Baumann et al. (2011), Dohmen (2008) and Dohmen and Sonnabend (2018), who discovered that left footed players enjoyed more penalty success and also the findings of Almeida et al. (2016) who discovered that footedness had no significant impact upon penalty success, suggesting this area requires further research.

The results also revealed an insight into the mental attributes of penalty takers across European football and particularly how players cope with the anxiety and pressure known to be associated with penalty kicks (Arrondel et al., 2019; Navia et al., 2019; Wood & Wilson, 2011). Penalty takers in the EPL preferred a more risk averse approach by directing the ball

centrally with some elevation (0.81-1.63 metres from the ground), whereas penalty takers in SLL, GB and ISA preferred a riskier approach of targeting the bottom corners of the goal with little elevation (less than 0.81 metres). Even though previous research has revealed that the probability of scoring is significantly higher when targeting the upper areas of the goal (Almeida et al., 2016; Bar-Eli & Azar, 2009), penalty takers in the EPL, GB or SLL did not target these areas. Only penalty takers in the ISA were revealed to target the upper areas of the goal suggesting they were more open to selecting the riskiest option (Navia et al., 2019). As stated by Bar-Eli and Azar (2009) players may tend to prefer the more risk averse options due to the fear of failure and the apprehension of being perceived as unskilled should they miss the target. Furthermore, Navia et al. (2019) also states that penalty takers prefer to have their penalty saved rather than missing the target which also explains these results.

Penalty takers in the GB appeared to be slightly more unpredictable as the results have revealed that they aimed for both sides of the goal as well as centrally but not in any of the three upper areas of goal. As argued by Almeida et al. (2016) and Noël et al. (2015), unpredictability can enhance shooting performance, particularly as modern day football players are well informed of their opponents past behaviours. Based on these findings, it seems that penalty takers in the GB are doing better than their European counterparts with regards to unpredictability, but could still enhance this further by aiming towards the upper parts of the goal.

Further information on the psyche of penalty takers is revealed when assessing the impact of the situational variable match status. Penalty takers in the EPL were more proficient when their team was losing, suggesting that penalty takers in the EPL are more efficient in conditions where there is the pressure of scoring a potential equaliser or scoring in order to get their team back in the game. Arrondel et al. (2019) stated that individuals are more likely to take more risks in the “loss” domain and be more conservative in the “gain” domain which

could explain this result. This would also coincide with the fact that penalty takers in the EPL tend to adopt the risk averse strategy of aiming centrally as opposed to penalty takers in other European leagues. On the contrary, penalty takers in the SLL and the ISA were more proficient when their team is drawing suggesting penalty takers in these nations relish the opportunity to score a potentially match winning goal. Penalty takers in the GB were most proficient when their team is winning suggesting they clinically execute penalty kicks when winning in order to further stretch their team's lead.

Time Period had no impact on penalty success in the EPL. Scoring in the last 15 minute period just before full-time had a significant impact on penalty success in the SLL, GB and the ISA. In a study on referee efficiency, Mallo et al. (2012) discovered that error rates peaked in the last 15 minutes of the match which could partially explain these results as some penalty kicks may have been erroneously awarded in this time period. Furthermore, studies have revealed that the greatest number of goals are scored in the final 15 minutes of matches and these often become match winning goals as the opposing teams having less time to respond (Armatas et al., 2007; Martínez & González-García, 2019). Being awarded a penalty in the 15 minute period just before half-time also had a significant impact on penalty success in the SLL and ISA. Analyses on goal scoring patterns have revealed that goals are often scored just before half-time and in the final five minutes of a match and these have been attributed to lapses in concentration and fatigue (Armatas et al., 2007), which could also explain the awarding of penalty kicks in these two time periods.

Venue had no significant impact upon penalty success in the EPL, however in the SLL and ISA winning a penalty kick at home had a significant impact upon penalty success. This could be partially explained by home teams being awarded more penalties (Dohmen, 2008; Memmert et al., 2013; Sutter & Kocher, 2004), thus having more opportunities to maximise this scoring opportunity. In the GB penalty kicks that were awarded away had a greater impact

401 upon penalty success rates. These results conform with those discovered by Dohmen (2008),
402 who discovered that penalty takers in the GB tend to "choke" more often when taking a penalty
403 at home rather than away.

404 The results offer an insight into the different styles of penalty technique adopted across
405 European leagues, particularly as players tend to aim towards different areas of the goal in
406 order to score, favouring different length run-ups and adopting varying striking techniques in
407 each league. Some of these variations could be attributed to coaching players have received
408 and general player development (Sarmento et al., 2018). As argued by Roe and Parker (2016),
409 the quality of coaching players receive varies from club-to-club in English football and this is
410 likely to apply across Europe, particularly as the levels of revenue earned varies from league-
411 to-league (Deloitte Football Money Report 2020).

412 From a practical perspective, the results of this study inform coaches, professional
413 players as well as other practitioners what can be specifically done to enhance penalty success
414 (from the penalty takers perspective) and subsequently decrease penalty success (from the
415 goalkeepers perspective) in the league in which they perform. Furthermore, the inter-league
416 and inter-league variations discovered in this study further highlight the impact geographical
417 and cultural factors can have on playing performance, reinforcing the claims of Sarmento et al.
418 (2013) and Mitrotasios et al. (2019) that football is practiced differently in every country.

419 Although this study reported high levels of intra-observer and inter-observer reliability,
420 there were some limitations associated with data collection. The variable time period did not
421 consist of equal 15 minute time periods as the third time period (30-HT) and last time period
422 (75-FT) contained some additional minutes due to injury time added on by the referee. If
423 possible, this should be controlled or accounted for in future studies. Furthermore, the variable
424 direction of the strike can potentially involve some ambiguity in interpretation, particularly
425 when the ball is directed between two or three neighbouring zones. To limit the impact of these

infrequent cases, the authors recommend some prior training as well as a clear and consistent understanding of the operational definitions.

For future research, we recommend further investigation into the inter-league and inter-nation variations between several other aspects of match analysis as well as further work on set-pieces. Future research could incorporate a greater number of penalty kicks from more elite football leagues worldwide as well as information on goalkeeper movements, off-target penalties and the impact of VAR (video assistance referee) recently implemented in European football leagues.

Conclusion

Evidence has been discovered proving that there are many different ways to score a penalty kick and that these successful methods vary across European leagues in different nations. The present findings recommend that coaches and players should pay special attention to run-up lengths, the direction of the strike, the type of strike and which foot the penalty is taken with as these variables directly influence penalty success and are within the penalty takers control. Penalty takers should also be made aware of the impact other situational variables such as time period, match status and venue have upon penalty success in order to enhance their psychological attributes. The inter-league and inter-nation variations of key determinants of penalty success discovered in this study could well be used to inform coaching philosophies across European football moving forward.

References

Almeida, C. H., Volossovitch, A., & Duarte, R. (2016). Penalty kick outcomes in UEFA club competitions (2010-2015): The roles of situational, individual and performance factors.

International Journal of Performance Analysis in Sport, *16*(2), 508–522. https://doi.org/10.1080/24748668.2016.11868905

Armatas, V., Yiannakos, A., Seaton, M., & Rigas, G. (2013). Home advantage: Comparison between professional and amateur Greek football leagues. *Journal of Sport and Health Research*, *5*(1), 95–106.

Armatas, V., Yiannakos, A., & Sileloglou, P. (2007). Relationship between time and goal scoring in soccer games: Analysis of three World Cups. *International Journal of Performance Analysis in Sport*, *7*(2), 48–58. https://doi.org/10.1080/24748668.2007.11868396

Arrondel, L., Duhautois, R., & Laslier, J. F. (2019). Decision under psychological pressure: The shooter's anxiety at the penalty kick. *Journal of Economic Psychology*, *70*(October 2018), 22–35. https://doi.org/10.1016/j.joep.2018.10.008

Bar-Eli, M., & Azar, O. H. (2009). Penalty kicks in soccer: An empirical analysis of shooting strategies and goalkeepers' preferences. *Soccer and Society*, *10*(2), 183–191. https://doi.org/10.1080/14660970802601654

Baumann, F., Friehe, T., & Wedow, M. (2011). General ability and specialization: Evidence from penalty kicks in soccer. *Journal of Sports Economics*, *12*(1), 81–105. https://doi.org/10.1177/1527002510371194

Brinkschulte, M., Furley, P., & Memmert, D. (2020). English football players are not as bad at kicking penalties as commonly assumed. *Scientific Reports*, *10*(1). https://doi.org/10.1038/s41598-020-63889-6

Cerrah, A. O., Özer, B., & Bayram, İ. (2016). Quantitative analysis of goals scored from set pieces: Turkey Super League application. *Turkiye Klinikleri Journal of Sports Sciences*, *8*(2), 37–45. https://doi.org/10.5336/sportsci.2016-50745

Cohen, J. (1988). *Statistical Power Analysis For The Behavioral Sciences* (2nd ed.). USA: L. Erlbaum Associates.

De Baranda, P. S., & Lopez-Riquelme, D. (2012). Analysis of corner kicks in relation to match status in the 2006 World Cup. *European Journal of Sport Science*, *12*(2), 121–129. https://doi.org/10.1080/17461391.2010.551418

Deloitte and Touche (2020). Football Money League, Deloitte and Touche: Manchester.

Dohmen, T. J. (2008). Do professionals choke under pressure? *Journal of Economic Behavior & Organization*, *65*(3–4), 636–653. https://doi.org/10.1016/j.jebo.2005.12.004

Dohmen, T., & Sonnabend, H. (2018). Further field evidence for minimax play. *Journal of Sports Economics*, *19*(3), 371–388. https://doi.org/10.1177/1527002516656729

Efron, B. & Tibshirani, R.J. (1993). *An Introduction to the Bootstrap*. USA: Chapman and Hall CRC.

Fariña, A. R., Fábrica, G., Tambusso, P. S., & Alonso, R. (2013). Taking the goalkeeper's side in association football penalty kicks. *International Journal of Performance Analysis in Sport*, *13*(1), 96–109. https://doi.org/10.1080/24748668.2013.11868634

Gai, Y., Leicht, A. S., Lago, C., & Gómez, M.-Á. (2019). Physical and technical differences between domestic and foreign soccer players according to playing positions in the China Super

League. *Research in Sports Medicine*, *27*(3), 314–325. https://doi.org/10.1080/15438627.2018.1540005

Hughes, M., & Wells, J. (2002). Analysis of penalties taken in shoot-outs. *International Journal of Performance Analysis in Sport*, *2*(1), 55–72. https://doi.org/10.1080/24748668.2002.11868261

Jamil, M. (2019). A case study assessing possession regain patterns in English Premier League Football. *International Journal of Performance Analysis in Sport*, *19*(6), 1011–1025. https://doi.org/10.1080/24748668.2019.1689752

Jamil, M., McErlain-Naylor, S. A., & Beato, M. (2020). Investigating the impact of the mid-season winter break on technical performance levels across European football – Does a break in play affect team momentum? *International Journal of Performance Analysis in Sport*, *20*(3), 406–419. https://doi.org/10.1080/24748668.2020.1753980

Kipsaina, K. J., Jepchirchir, K. J., & Boit, K. M. (2017). Teacher-trainee preparedness on integration of ICT for instruction in selected public teacher training colleges in north rift, Kenya. *Advances in Social Sciences Research Journal*, *4*(5), 29–43. https://doi.org/10.14738/assrj.45.2697

Lees, A., & Owens, L. (2011). Early visual cues associated with a directional place kick in soccer. *Sports Biomechanics*, *10*(02), 125–134. https://doi.org/10.1080/14763141.2011.569565

Liu, H., Hopkins, W., Gómez, A. M., & Molinuevo, S. J. (2013). Inter-operator reliability of live football match statistics from OPTA Sportsdata. *International Journal of Performance Analysis in Sport*, *13*(3), 803–821. https://doi.org/10.1080/24748668.2013.11868690

López-Botella, M., & 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. https://doi.org/10.1080/24748668.2007.11868407

Mackenzie, R., & Cushion, C. (2013). Performance analysis in football: A critical review and implications for future research. *Journal of Sports Sciences*, *31*(6), 639–676. https://doi.org/10.1080/02640414.2012.746720

Mallo, J., Frutos, P. G., Juárez, D., & Navarro, E. (2012). Effect of positioning on the accuracy of decision making of association football top-class referees and assistant referees during competitive matches. *Journal of Sports Sciences*, *30*(13), 1437–1445. https://doi.org/10.1080/02640414.2012.711485

Martínez, F., & González-García, H. (2019). Effect of scoring first and match period in football world cup and UEFA. *European Journal of Human Movement*, *42*(0), 123–137.

Memmert, D., Hüttermann, S., Hagemann, N., Loffing, F., & Strauss, B. (2013). Dueling in the penalty box: evidence-based recommendations on how shooters and goalkeepers can win penalty shootouts in soccer. *International Review of Sport and Exercise Psychology*, *6*(1), 209–229. https://doi.org/10.1080/1750984X.2013.811533

Mitrotasios, M., Gonzalez-Rodenas, J., Armatas, V., & Aranda, R. (2019). The creation of goal scoring opportunities in professional soccer. Tactical differences between Spanish La Liga, English Premier League, German Bundesliga and Italian Serie A. *International Journal of Performance Analysis in Sport*, *19*(3), 452–465. https://doi.org/10.1080/24748668.2019.1618568

Navia, J. A., van der Kamp, J., Avilés, C., & Aceituno, J. (2019). Self-Control in aiming supports coping with psychological pressure in soccer penalty kicks. *Frontiers in Psychology*, *10*(JUN), 1–8. https://doi.org/10.3389/fpsyg.2019.01438

Noël, B., Furley, P., van der Kamp, J., Dicks, M., & Memmert, D. (2015). The development of a method for identifying penalty kick strategies in association football. *Journal of Sports Sciences*, *33*(1), 1–10. https://doi.org/10.1080/02640414.2014.926383

Pulling, C. (2015). Long corner kicks in the English Premier League: Deliveries into the goal area and critical area. *Kinesiology*, *47*(2), 193–201.

Roe, C., & Parker, A. (2016). Sport, chaplaincy and holistic support: The elite player performance plan (EPPP) in English professional football. *Practical Theology*, *9*(3), 169–182. https://doi.org/10.1080/1756073X.2016.1221638

Sarmento, H., Clemente, F. M., Araújo, D., Davids, K., McRobert, A., & Figueiredo, A. (2018). What performance analysts need to know about research trends in Association Football (2012–2016): A Systematic Review. *Sports Medicine*, *48*(4), 799–836. https://doi.org/10.1007/s40279-017-0836-6

Sarmento, H., Pereira, A., Matos, N., Campaniço, J., Anguera, T. M., & Leitão, J. (2013). English Premier League, Spaiṅs La Liga and Italýs Seriés A – What's different? *International Journal of Performance Analysis in Sport*, *13*(3), 773–789. https://doi.org/10.1080/24748668.2013.11868688

Selya, A. S., Rose, J. S., Dierker, L. C., Hedeker, D., & Mermelstein, R. J. (2012). A practical guide to calculating Cohen's f2, a measure of local effect size, from PROC MIXED. *Frontiers in Psychology*, *3*(APR), 1–6. https://doi.org/10.3389/fpsyg.2012.00111

554 Shafizadeh, M., Sproule, J., & Gray, S. (2013). The emergence of coordinative structures
555 during offensive movement for goal-scoring in soccer. *International Journal of Performance*
556 *Analysis in Sport*, *13*(3), 612–623. https://doi.org/10.1080/24748668.2013.11868675

557 Sutter, M., & Kocher, M. G. (2004). Favoritism of agents - The case of referees' home bias.
558 *Journal of Economic Psychology*, *25*(4), 461–469. https://doi.org/10.1016/S0167-
559 4870(03)00013-8

560 Timmis, M. A., Turner, K., & van Paridon, K. N. (2014). Visual search strategies of soccer
561 players executing a power vs. placement penalty kick. *PLoS ONE*, *9*(12), e115179.
562 https://doi.org/10.1371/journal.pone.0115179

563 Viera, A. J., & Garrett, J. M. (2005). Understanding interobserver agreement: the kappa
564 statistic. *Family Medicine*, *37*(5), 360–363.

565 Wood, G., & Wilson, M. R. (2011). Quiet-eye training for soccer penalty kicks. *Cognitive*
566 *Processing*, *12*(3), 257–266. https://doi.org/10.1007/s10339-011-0393-0

567 Yiannakos, A., & Armatas, V. (2006). Evaluation of the goal scoring patterns in European
568 Championship in Portugal 2004. *International Journal of Performance Analysis in Sport*, *6*(1),
569 178–188. https://doi.org/10.1080/24748668.2006.11868366

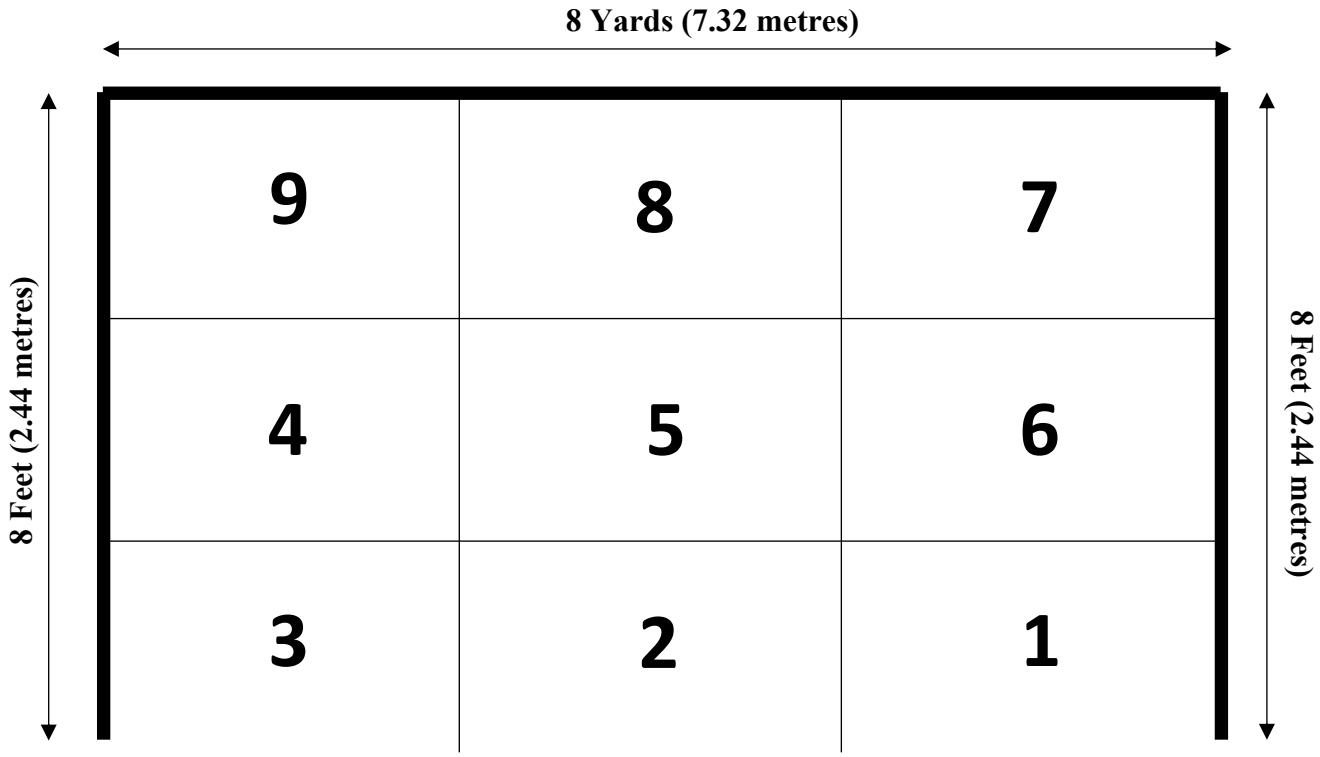

Figure 1 – Location of the goal where the ball was struck (*each zone measured approximately **H**2.67 feet x **W**2.67 Yards*)

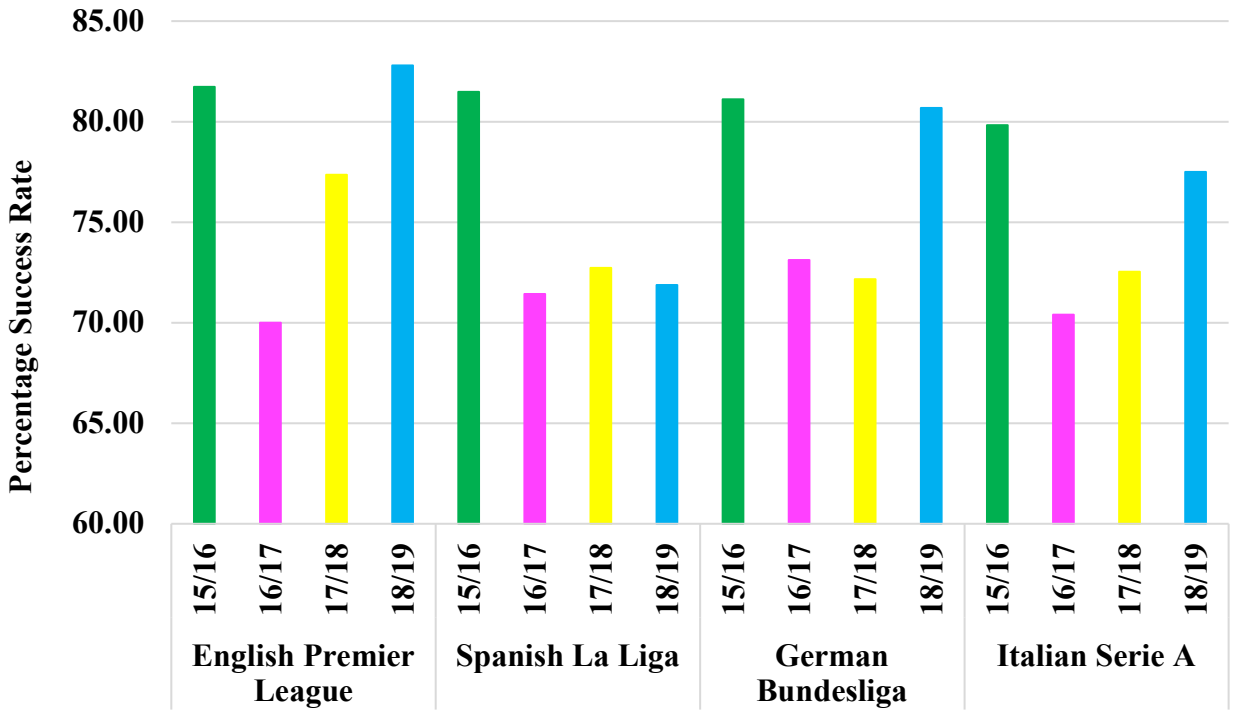

Figure 2 – Cumulative penalty success rates for each European league across each season

Table 1 – Independent variables list and the respective operational definitions

Type of Shot (Power)	Instep technique where the focus is on ball speed rather than accuracy
Type of Shot (Placement)	Side-foot technique where the focus is on accuracy rather than ball speed
Type of Shot (Chipped)	A "Panenka" type chipped technique
Location of Strike (Zone 1)	Low right corner (from the penalty takers perspective) with approximately less than 2.67 feet of elevation
Location of Strike (Zone 2)	Low centre (from the penalty takers perspective) with approximately less than 2.67 feet of elevation
Location of Strike (Zone 3)	Low left corner (from the penalty takers perspective) with approximately less than 2.67 feet of elevation
Location of Strike (Zone 4)	Middle left (from the penalty takers perspective) with approximately 2.67 - 5.34 feet of elevation
Location of Strike (Zone 5)	Middle centre (from the penalty takers perspective) with approximately 2.67 - 5.34 feet of elevation
Location of Strike (Zone 6)	Middle right (from the penalty takers perspective) with approximately 2.67 - 5.34 feet of elevation
Location of Strike (Zone 7)	Top right corner (from the penalty takers perspective) with approximately 5.34 - 8 feet of elevation
Location of Strike (Zone 8)	Top centre (from the penalty takers perspective) with approximately 5.34 - 8 feet of elevation
Location of Strike (Zone 9)	Top left corner (from the penalty takers perspective) with approximately 5.34 - 8 feet of elevation
Length of Run-up (Short)	Less than 2 steps prior to striking the ball
Length of Run-up (Medium)	2-5 steps prior to striking the ball
Length of Run-up (Long)	6 or more steps prior to striking the ball
Penalty Taker's Preferred Foot (R)	Right footed penalty strike
Penalty Taker's Preferred Foot (L)	Left footed penalty strike
Venue (Home)	Penalty kick taken at home venue
Venue (Away)	Penalty kick taken at an away venue
Match Status (Winning)	Penalty kick taken when the takers team was already winning
Match Status (Drawing)	Penalty kick taken when the takers team was drawing
Match Status (Losing)	Penalty kick taken when the takers team was already losing
Time Period (0-15)	Penalty kick taken during the opening 15 minutes of the game
Time Period (15-30)	Penalty kick taken between 15-30 minutes of the game
Time Period (30-HT)	Penalty kick taken between 30 minutes and Half Time
Time Period (HT-60)	Penalty kick taken between Half Time and 60 minutes of the game
Time Period (60-75)	Penalty kick taken between 60-75 minutes of the game
Time Period (75-FT)	Penalty kick taken between 75 minutes and Full Time

Table 2 – Cohen's f^2 global effect sizes for each independent variable

Variable	EPL	SLL	GB	ISA
Run-up Length	0.12 (*Small*) p = 0.1772	0.32 (*Medium*) p = 0.0007***	0.32 (*Medium*) p = 0.0038***	0.26 (*Medium*) p = 0.006***
Direction of Strike	0.19 (*Medium*) p = 0.2386	0.35 (*Large*) p = 0.0374**	0.51 (*Large*) p = 0.0088***	0.33 (*Medium*) p = 0.0240**
Match Status	0.12 (*Small*) p = 0.1306	0.35 (*Large*) p = 0.0001***	0.37 (*Large*) p = 0.0007***	0.27 (*Medium*) p = 0.0012***
Time Period	0.13 (*Small*) p = 0.3220	0.42 (*Large*) p = 0.0001***	0.37 (*Large*) p = 0.0161**	0.28 (*Medium*) p = 0.0052***
Type of Strike	0.11 (*Small*) p = 0.1599	0.34 (*Medium*) p = 0.0020***	0.31 (*Medium*) p = 0.0056***	0.25 (*Medium*) p = 0.0024***
Venue	0.11 (*Small*) p = 0.0844	0.32 (*Medium*) p = 0.0009***	0.31 (*Medium*) p = 0.0010***	0.29 (*Medium*) p = 0.0008***
Preferred Foot	0.10 (*Small*) p = 0.0617	0.32 (*Medium*) p = 0.0008***	0.29 (*Medium*) p = 0.0018***	0.24 (*Medium*) p = 0.005***

S = *Small effects,* M = *Medium effects,* L = *Large effects*
Global χ^2 p - values are also reported, *** = Significant at 99% CI, ** = Significant at 95% CI

Table 3 – Bootstrapped regression results

Country	English Premier League			Spanish La Liga			German Bundesliga			Italian Serie A		
Independent Variables	**Coefficient**	**z**	**p > (z)**	**Coefficient**	**z**	**p > (z)**	**Coefficient**	**z**	**p > (z)**	**Coefficient**	**z**	**p > (z)**
Short Run Up	4.825	1.39	0.165	4.028	1.05	0.293	5.762	0.97	0.330	-0.215	-0.02	0.982
Medium Run Up	4.214	2.00	0.046**	4.027	3.75	0.000***	7.146	3.61	0.000***	2.478	1.78	0.075
Long Run Up	2.891	2.12	0.034**	4.42	3.52	0.000***	5.94	2.97	0.003***	3.679	4.09	0.000***
L1 (Bottom Right)	4.458	1.50	0.134	4.364	2.62	0.009***	2.657	1.13	0.259	5.571	2.87	0.004***
L2 (Bottom Centre)	2.165	0.58	0.564	5.093	1.34	0.182	12.096	3.24	0.001***	4.167	1.08	0.278
L3 (Bottom Left)	4.068	1.44	0.150	3.761	1.98	0.048**	7.805	2.89	0.004***	2.697	1.97	0.049**
L4 (Middle Left)	-2.044	-0.62	0.536	3.748	0.84	0.401	7.494	1.84	0.066	-0.066	-0.02	0.981
L5 (Middle Centre)	9.955	2.97	0.003***	1.263	0.32	0.752	9.117	0.77	0.444	1.934	0.42	0.672
L6 (Middle Right)	-0.893	-0.18	0.859	5.542	1.83	0.068	13.264	2.60	0.009***	8.057	1.64	0.101
L7 (Top Right)	5.622	1.00	0.320	4.755	1.25	0.213	8.508	1.39	0.163	-2.832	-0.36	0.717
L8 (Top Centre)	7.724	1.14	0.255	7.561	1.65	0.099	-4.556	-0.47	0.638	8.180	2.00	0.046**
L9 (Top Left)	6.018	1.21	0.224	8.903	1.14	0.254	8.290	0.96	0.339	1.271	0.29	0.768
TOS (Power)	2.882	1.47	0.141	5.006	3.24	0.001***	7.383	2.43	0.015**	3.349	2.83	0.005***
TOS (Placement)	3.633	2.10	0.036**	4.408	3.22	0.001***	6.162	3.35	0.001***	3.496	3.03	0.002***
TOS (Chip)	0.838	0.12	0.908	1.593	0.29	0.771	2.320	0.21	0.834	0.141	0.03	0.973
Preferred Foot (Right)	3.346	2.36	0.018**	4.120	3.65	0.000***	6.278	3.54	0.000***	3.347	3.84	0.000***
Preferred Foot (Left)	4.076	1.42	0.157	4.496	3.25	0.001***	5.988	2.69	0.007***	3.299	2.83	0.005***
Match Status (D)	1.620	0.76	0.445	5.740	4.42	0.000***	4.212	2.31	0.021**	5.141	3.30	0.001***
Match Status (W)	4.913	1.84	0.066	2.812	1.72	0.085	8.937	3.54	0.000***	2.039	1.78	0.076
Match Status (L)	4.493	2.17	0.030**	3.747	2.35	0.019**	8.794	3.26	0.001***	3.118	2.21	0.027**
TP (0-15)	0.338	0.08	0.934	-1.551	-0.51	0.611	2.857	0.62	0.537	5.319	1.81	0.07
TP (15-30)	3.04	0.89	0.376	3.642	1.83	0.067	6.007	1.48	0.139	1.819	0.83	0.408
TP (30 – HT)	5.168	1.80	0.072	5.131	2.67	0.008***	4.374	1.69	0.091	5.376	2.69	0.007***
TP (45-60)	1.802	0.59	0.557	7.035	3.62	0.000***	6.023	1.74	0.082	2.893	1.20	0.229
TP (60 – 75)	6.234	1.78	0.075	3.074	1.44	0.149	5.597	1.32	0.187	1.372	0.67	0.504
TP (75 - FT)	3.009	1.31	0.191	4.350	2.65	0.008***	10.018	3.63	0.000***	4.018	2.29	0.022**
Venue (Home)	3.949	1.85	0.064	4.589	3.49	0.000***	6.132	3.43	0.001***	4.665	3.65	0.000***
Venue (Away)	2.899	1.68	0.093	3.651	2.95	0.003***	6.514	2.55	0.011**	1.520	1.34	0.180

*** = Significant at 99% CI, ** = Significant at 95% CI
All coefficient values are unstandardised

Table 4 – Cohen's f^2 local effect sizes for each class of independent variables

Variable	EPL	SLL	GB	ISA
Short Run Up	-	-	-	-
Medium Run Up	0.09 (*Small*)	0.19 (*Medium*)	0.24 (*Medium*)	-
Long Run Up	0.06 (*Small*)	0.23 (*Medium*)	0.18 (*Medium*)	0.25 (*Medium*)
L1 (Bottom Right)	-	0.09 (*Small*)	-	0.12 (*Small*)
L2 (Bottom Centre)	-	-	0.14 (*Small*)	-
L3 (Bottom Left)	-	0.06 (*Small*)	0.15 (*Medium*)	0.05 (*Small*)
L4 (Middle Left)	-	-	-	-
L5 (Middle Centre)	0.08 (*Small*)	-	-	-
L6 (Middle Right)	-	-	0.08 (*Small*)	-
L7 (Top Right)	-	-	-	-
L8 (Top Centre)	-	-	-	0.05 (*Small*)
L9 (Top Left)	-	-	-	-
TOS (Power)	-	0.16 (*Medium*)	0.11 (*Small*)	0.08 (*Small*)
TOS (Placement)	0.07 (*Small*)	0.21 (*Medium*)	0.23 (*Medium*)	0.15 (*Medium*)
TOS (Chip)	-	-	-	-
Preferred Foot (Right)	0.1 (*Small*)	0.27 (*Medium*)	0.27 (*Medium*)	0.23 (*Medium*)
Preferred Foot (Left)	-	0.15 (*Medium*)	0.1 (*Small*)	0.09 (*Small*)
Match Status (D)	-	0.23 (*Medium*)	0.09 (*Small*)	0.16 (*Medium*)
Match Status (W)	-	-	0.19 (*Medium*)	-
Match Status (L)	0.05 (*Small*)	0.06 (*Small*)	0.2 (*Medium*)	0.06 (*Small*)
TP (0-15)	-	-	-	-
TP (15-30)	-	-	-	-
TP (30 – HT)	-	-	-	0.08 (*Small*)
TP (45-60)	-	-	-	-
TP (60 – 75)	-	-	-	-
TP (75 - FT)	-	0.08 (*Small*)	0.22 (*Medium*)	0.07 (*Small*)
Venue (Home)	-	0.21 (*Medium*)	0.18 (*Medium*)	0.25 (*Medium*)
Venue (Away)	-	0.09 (*Small*)	0.11 (*Small*)	-

S = *Small effects,* M = *Medium effects,* L = *Large effects.*
* Local effects sizes displayed for significant metrics only

Table 5 – Kappa statistics for intra-operator and inter-operator reliability

Variable	Intra-Operator Kappa statistic	Inter-Operator Kappa statistic
Length of Run-Up	0.98	0.97
Direction of Strike	0.98	0.97
Type of Shot	0.98	0.98
Preferred Foot	1	1
Match Status	1	1
Time Period	1	1
Venue	1	1

0 = Chance agreement, 1 = perfect agreement (Viera & Garrett, 2005)