Development of a data-based interval kicking program for preparation and rehabilitation purposes in professional football

Rod Whiteley[a], Abdulaziz Farooq[b] and Amanda Johnson[c]

[a]Rehabilitation Department, Aspetar Sports Medicine Hospital, Doha, Qatar; [b]Research Department, Aspetar Sports Medicine Hospital, Doha, Qatar; [c]Rehabilitation Department, Aspire Academy, Doha, Qatar

ABSTRACT

Study Design: Cross-sectional Observational Cohort Study. Level of Evidence: 3.

Objectives: Document kicking loads of professional soccer players in match play, and describe differ-ences in velocity-based and distance-based classification. Describe a kicking programme suitable for physical preparation or return to play.

Background: To determine reasonable kicking loads (volume and intensity) to plan for preparation and rehabilitation, normal match loads of kicking need to be described. It is not known if the kicking demands vary by playing position.

Methods: Match analysis data for the entire 2012 season of the US Major League Soccer was examined using both a distance-based and velocity-based approach. Number and types of kicks were described for each playing position using both approaches.

Results: Distance and velocity-based approaches were not seen to be equivalent, and a velocity-based approach was seen to be more reflective of the true kicking demands. The number and type of kicks made in each of the categories were seen to vary by playing position. On average, per game, goal-keepers made the fewest "slow" (0–6 m $\cdot s^{-1}$) kicks with 24.3 (9.1), left midfielders the most with 68.0 (32.2). Goalkeepers made the fewest "medium" (6–12 m $\cdot s^{-1}$) kicks with 9.1 (4.1) and central midfielders made the most with 36.8 (15.3). Attackers made the fewest "fast" (>12 m $\cdot s^{-1}$) kicks with 16.9 (10.1) while the left and right backs made the most with 30.8 (9.8).

Conclusion: Kicking load varies by position and is best described using a velocity-based approach. These data can to inform physical preparation for kicking loads.

Introduction

Professional soccer (football as it is termed in much of the world) is the most popular sport in the world for both participants and spectators (Junge et al. 2002; Kunz 2007). In other sports, for example, baseball, data-based throwing programmes have been developed (Axe & Konin 1992; Axe et al. 1996, 2001), and rules of the game have been changed to reflect the throwing loads considered safe. It is suggested that by considering the actual match demands, and appropriately prescribing rehabilitation tasks to ultimately meet or exceed these, a more durable and predictable return to play process can be fostered. The inclusion of such information is thought to have contributed to improved athlete preparation and reduced injury incidence.

Recently, kicking has been identified as the primary mechanism of acute muscle injury (40%), in adductor-related groin pain and rectus femoris injury in soccer players (Serner et al. 2015). Kicking, therefore, is primary risk factor in these important injuries, while kicking performance ability is central to all soccer players. Restoring the physical health of an injured athlete, or improving the physical performance of a healthy individual has been seen as conforming to the progressive overload principle since its formal description over 50 years ago (Hellebrandt 1958). The volume and intensity of kicking required during match play should be considered in describing a programme of preparation for return to play after injury or an extended absence (Creighton et al. 2010). During rehabilitation and return to play after injury or other breaks from play, a graded reintroduction of kicking loads culminating in replication of demands required for match play is considered a cornerstone of clinical reasoning (Jones 1992; Edwards et al. 2004; Creighton et al. 2010). Defining what constitutes the upper limits of soccer kicking loading in terms of volume, intensity, and frequency requires knowledge of normal match demands in terms of kicking loads. To our knowledge, these data are not available. Similarly, while it is likely that there are different kicking demands for different playing positions (e.g., goal-keeper, attacker) which should inform kicking load there are no data to support this conjecture.

Modern physical preparation of soccer players considers information regarding the match demands in terms of running distances and velocities required as they relate to individual positions, as well as varying levels of play in different leagues (Bradley et al. 2011b; Carling 2013; Paul

et al. 2015; Bush et al. 2015a). Such preparation methods have likely contributed to better physical performance parameters demonstrated, and the apparent steady increase in the pace of the modern game (Barnes et al. 2014; Bush et al. 2015a). The introduction of performance analysis technology at the highest level of soccer has allowed the support teams to accurately document individual player movements and activity, including all kicking events. The veracity of these methods has been well documented and has been used in performance analysis of soccer in a variety of studies (Di Salvo et al. 2007; Bradley et al. 2009; Gregson et al. 2010). Even though running loads are well described, it is surprising to learn that kicking loads have not, as yet, been documented, and it is currently not known what volume, variety, and intensity of kicking is required of a professional soccer player, nor if there is any variation in different positional requirements. In an effort to address this gap recently a kicking programme has been proposed based on expert opinion (Arundale et al. 2015); however, it is unknown how well the loads involved reflect actual game loading. This recommended programme (Arundale et al. 2015) suggested that kicking loads do not vary according to position, and proposed a time-based quantification of kicking loads in the absence of firm evidence of actual required match play kicking demands.

Accordingly, the primary aim of this paper is to document the kicking loads of professional soccer players during match play. The secondary aims are to develop descriptions of a data-based interval kicking programme, and to examine for any differences in kicking loads when considering different playing positions.

Methods

Data was extracted with the assistance of Prozone® on the US Major League Soccer for the entire 2012 season which comprised 338 games played by 504 players in 19 teams, from 10 March 2012 through 1 December 2012. The Prozone system comprises a combination of automatic player tracking and event detection using 8 calibrated cameras and dedicated software, which is then verified by a manual (human) quality control process. Validation studies have shown intraclass correlation between Prozone estimation and light gate measurement of player movement to be between 0.950 and 0.999 with typical error between 0.2% and 1.3% (Di Salvo et al. 2006).

Prozone categorizations of events in soccer include physical positional information of individual players, the ball, as well as technical and tactical information regarding events (e.g., pass, shot on goal, ball out of play, tackle, etc., see supplementary material: Prozone definitions of events) which are collected at 25 Hz. Accordingly by using the field coordinates of the ball, information is able to be derived regarding both the two-dimensional distance (from Pythagorean extrapolation) as well as velocity (given time-coding) of the passage of the ball, and the individual player involved. Practically it is possible to describe for every kicking event the starting and final ball position, along with the times of these (and therefore the velocity), as well as a description of the type of kicking event.

The research was conducted in accordance with the Declaration of Helsinki (World Medical Association 2013), and the permission and assistance of Prozone Sports.

Categorization of kicking events

As there are no formally accepted categorizations of kicking events either in the literature or commonly used in practice, before any analyses could be conducted, appropriate definitions had to be created. The authors surveyed 10 experts in soccer coaching and soccer sports science/physical preparation. These experts each had a minimum of 10 years' involvement (up to 25 years) in European professional soccer ranging from first division in national European leagues to International and English Premier League. Categorizing the events was a four-stage process. Initially agreement was sought on the appropriate number of categories for kicking intensity, and consensus was achieved at 3, which were hoped to reflect low, medium, and high intensity kicks as this was thought to be a practically achievable level of discrimination for kicking intensity.

Subsequently, the definitions of each of these categories needed to be decided upon. It was agreed that since the primary aim was to inform a kicking programme, the greatest volume of kicks should be in the lowest intensity category, and the smallest volume in the highest intensity category such that each category would be reflecting a more similar net player loading when considering together volume and intensity of kicks performed. Next, it was agreed that to facilitate uptake, these categories needed to be conveniently defined (for practitioners) with cut-points that were practical to implement, as well as reflecting what was considered to be low, medium, and high intensity kicking efforts. A number of different categorizations were then explored to examine relative frequencies of different kicks observed in the 829,645 events available for analysis. At the end of this exploration two approaches were agreed upon. For a distance-based analysis, categories of: 0–12, 12–30, and 30 m+ kicking events were described. For a velocity-based analysis, categories of 0–6, 6–12, and >12 $m \cdot s^{-1}$ were described.

Does a distance-based or velocity-based analysis better reflect kicking loading?

Two distinct approaches to quantifying the load of an individual kick were seen as plausible: the distance a kick travelled, and the velocity of the kicked ball. In a practical sense, if these two were seen to be essentially equivalent, then it would be more practical to describe a distance-based kicking protocol as these parameters could be readily described in terms related to the size of a soccer field. Of course, during a game, it is entirely likely that balls could be kicked at different velocities, and yet travel the same distance (to a team-mate in the example of a pass, or to the goal in the example of a shot), however it was unknown whether players adjusted their kicking intensity (velocity) to match the required distance in a systematic manner.

Estimations were then made of total kicking volume for every individual player, normalized to the median time on the pitch of all players, with the player starting position (for that game) noted. Frequency histograms with reference

Table 1. Distance-based categorizations by player starting position.

	Short (0–12 m)	SD	Middle (12–30 m)	SD	Long (>30 m)	SD
Attacker	80.59	*39.09*	11.92	*8.13*	3.54	*3.91*
Left midfield	106.77	*45.02*	16.14	*8.17*	6.19	*5.18*
Central midfield	96.31	*44.34*	21.07	*9.73*	8.10	*5.61*
Right midfield	102.25	*44.32*	16.44	*8.75*	5.99	*4.90*
Left back	84.86	*33.17*	23.51	*7.31*	10.16	*4.63*
Central back	60.48	*29.37*	22.18	*9.53*	9.17	*4.73*
Right back	84.86	*33.17*	23.51	*7.31*	10.16	*4.63*
Goalkeeper	26.56	*9.90*	9.16	*4.35*	21.19	*7.08*

Values represent the mean number of kicks made and SD for the three categories of kick, for a game lasting 94.14 min (the median game length of all games played in the 2012 season).

normal curves were generated (supplementary material 1) and inspected for each of the categorizations along with tests of normality (Kolomogorov–Smirnov and Shapiro–Wilk, and *Q*–*Q* plots). The velocity-based approach was shown to more often be normally distributed, this was especially evident in the "long" classifications where the data were positively skewed in many cases where there were a large number of positions performing no, or few "long" kicks. This allowed meaningful description of average and standard deviations for each of the three velocity categories for each starting position. To determine the effect of the factors: player position (8 levels) and speed (3 levels – slow, medium, fast) on kicking load, a linear mixed models analysis accounting for intra-subject correlation was performed. Appropriate covariance structure was selected as a random effect that provided the smallest Akaike Information Criteria (AIC). For significant effects, *post hoc* pair-wise comparisons were performed by applying Sidak correction.

Analysis of these volumes by individual position showed substantial differences in these categorizations of kicking load by position (see Tables 1 and 2, and Figures 1 and 2). For example, the highest proportion (28%) of longest distance kicks (>30 m) were seen to be made by goal keepers, however a velocity-based analysis showed goal keepers to have made the second lowest absolute number of high velocity (>12 m · s^{-1}) kicks (12% compared to 8% for attackers). We rationalize that distance-based categorization by goal-keepers over estimates kicking load as the ball is often kicked "long" (especially in goal kicks, and clearances), and these have the opportunity to travel much further than another hard kick made by a player, which travels to a team-mate, or towards the goal. An attacker by contrast has little chance to kick the ball "long" (as they typically are playing forward) but has every opportunity to kick the ball "fast" (when shooting at goal, for example).

With this information, consultation with experts in the field of soccer training and injury was conducted. A consensus was readily achieved that despite the practicality of a distance-based protocol, a velocity-based approach much better reflected actual load of kicking. Accordingly, for the remainder of the analysis we used velocity-based categorizations.

Results

A total of 9275 player game appearances were documented with a mean time on the pitch of 76.35 min (SD: 29.26), and a median of 94.14 (IQR: 63.38–96.04) minutes (range: 0.3–103.4 min). The distance-based quantification of kicking load is shown in Table 1 and Figure 1 while the velocity-based data is shown in Table 2 and Figure 2. Figure 3 depicts the percentages of the individual kicking events for each starting position when classified according to event type as well as the interval kicking programme that it informs.

For the "Slow" kicks, all 28 pair-wise comparisons of positions had significantly different numbers of normalized kicks per game ($P < 0.01$) with the exception of the left and right backs ($P = 0.958$). For the "Medium" category of kicks, 17 of the 28 pair-wise comparisons of positions had significantly different ($P < 0.01$) numbers of kicks with the exceptions of the following pairs: attacker and central back ($P = 0.194$); central midfield and each of: left back ($P = 0.795$), right back ($P = 0.588$), left midfield ($P = 1.000$), and right midfield ($P = 0.999$) (4 further pair-wise comparisons); left back and each of: right back ($P = 1.000$), left midfield ($P = 0.893$), and right midfield ($P = 1.000$) (3 further pair-wise comparisons); left midfield and each of: right midfield ($P = 1.000$), and right back ($P = 0.750$) (2 further pair-wise comparisons); and right back with right midfield ($P = 1.000$, 1 further pair-wise comparison).

For the "fast" category of kicks, 21 of the 28 pair-wise comparisons were significantly different ($P < 0.05$) with the exceptions of: central back and each of: goal keeper ($P = 0.942$); left midfield (0.226); and right midfield ($P = 0.263$); goalkeeper and each of left midfield ($P = 1.000$) and right midfield ($P = 1.000$) (2 further pair-wise comparisons); left back and right back ($P = 1.000$) (1 further pair-wise comparison); left midfield and right midfield ($P = 1.000$) (1 further pair-wise comparison)

The between group differences for each of the 168 pair-wise comparisons along with the 95% confidence intervals, *P*-values, and summary statistics are provided in Table 3.

Table 2. Velocity-based categorizations by player starting position.

	Slow (0–6 m · s^{-1})	SD	Medium (6–12 m · s^{-1})	SD	Fast (>12 m · s^{-1})	SD
Attacker	50.57	*27.74*	28.26	*14.54*	16.89	*10.12*
Left midfield	67.96	*32.17*	36.42	*15.66*	24.33	*11.91*
Central midfield	61.38	*31.48*	36.75	*15.32*	27.00	*12.78*
Right midfield	64.57	*32.33*	35.45	*14.91*	24.28	*12.23*
Left back	53.06	*22.40*	34.50	*12.37*	30.77	*9.76*
Central back	42.64	*23.05*	26.48	*10.74*	22.60	*9.75*
Right back	53.06	*22.40*	34.50	*12.37*	30.77	*9.76*
Goalkeeper	24.30	*9.12*	9.07	*4.14*	23.52	*6.70*

Values represent the mean number of kicks made and SD for the three categories of kick for a game lasting 94.14 min (the median game length of all games played in the 2012 season).

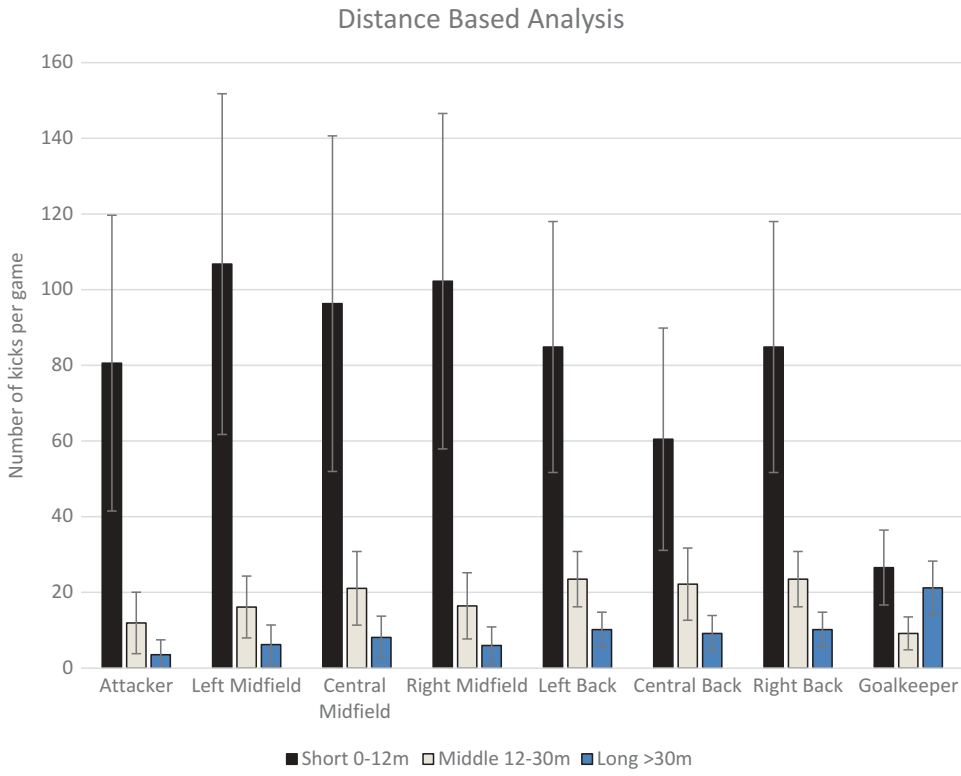


Figure 1. Mean (SD) numbers of kicks by each playing position for the 3 distance-based categorizations, for a game lasting 94.14 min (the median length of all games played in the 2012 season). The three distance categorizations represent the distances the ball travelled for each kick, and are classified as: short: 0–12 m, middle: 12–30 m, and long: >30 m.

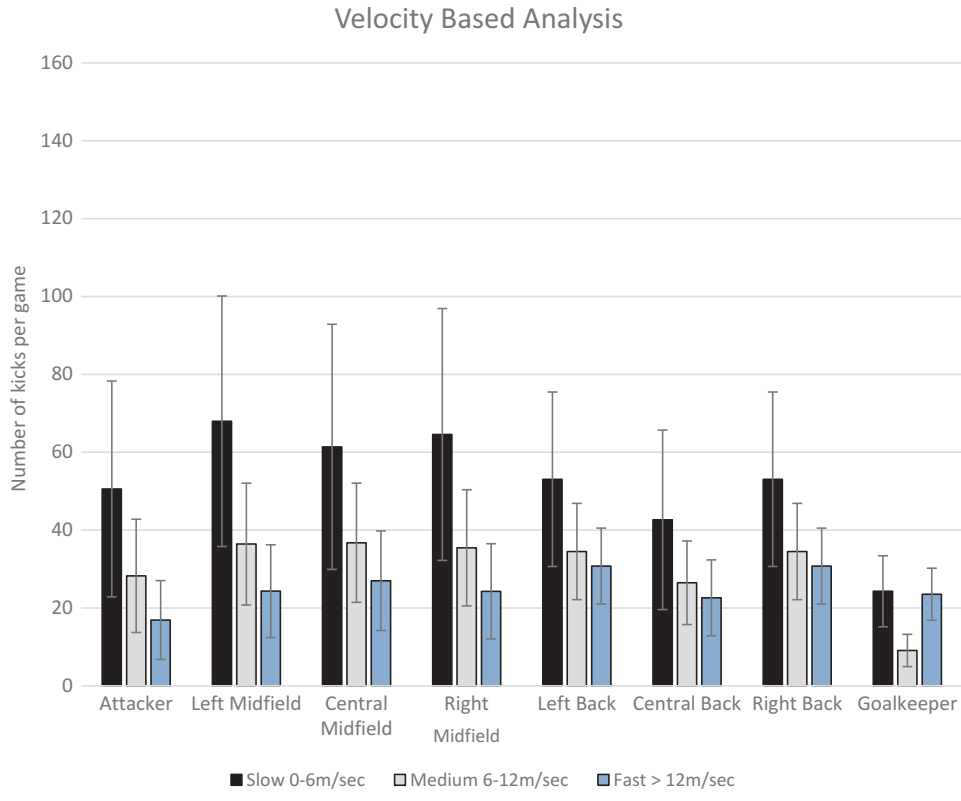
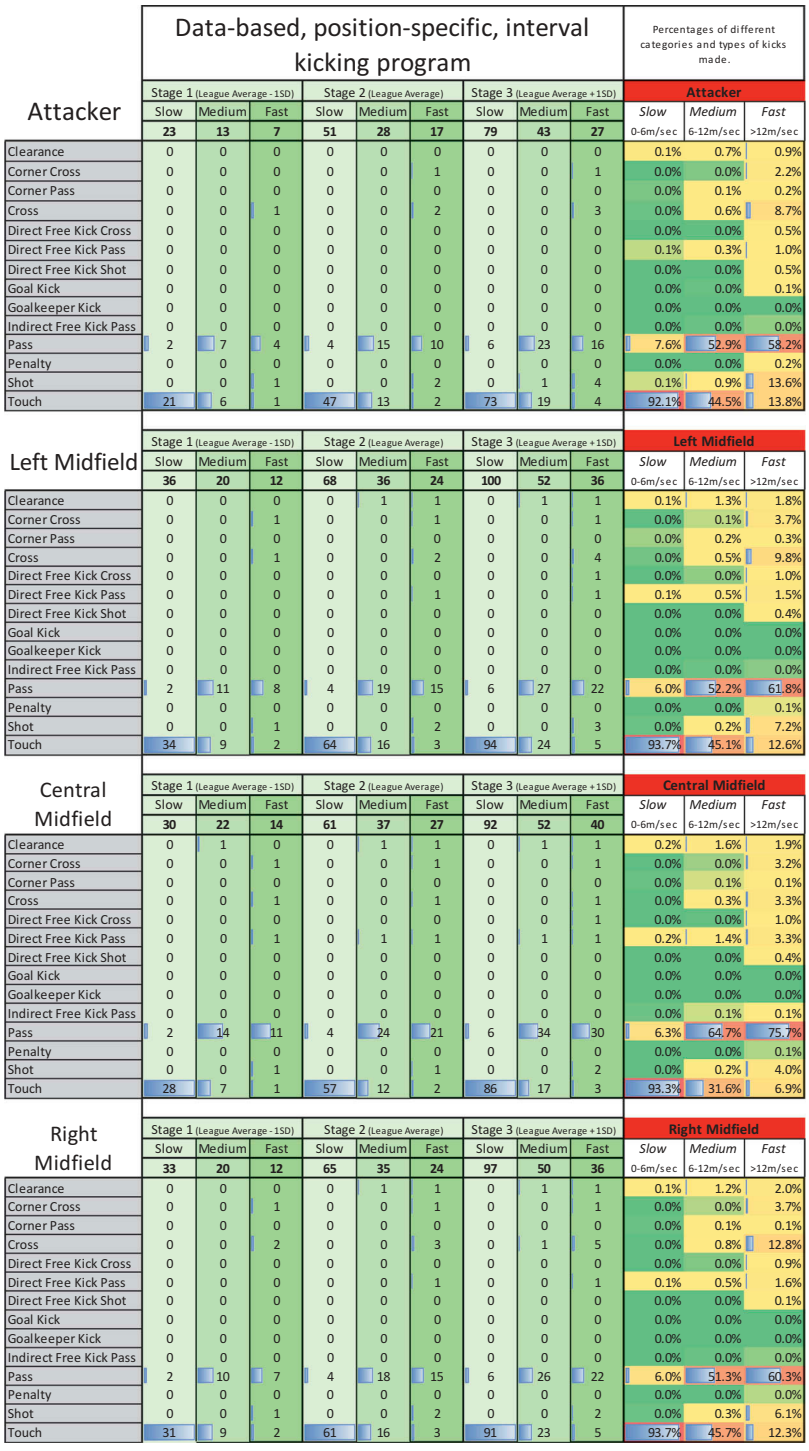


Figure 2. Mean (SD) numbers of kicks by each playing position for the 3 velocity-based categorizations for a game lasting 94.14 min (the median length of all games played in the 2012 season). The three velocity-based categorizations represent the average two-dimensional speed of the ball for each kick, and are classified as: slow: 0–6 m · s^{-1}; medium: 6–12 m · s^{-1}; and fast: >12 m · s^{-1}.



Data-based, position-specific, interval kicking program

Percentages of different categories and types of kicks made.

Attacker

	Stage 1 (League Average - 1SD)			Stage 2 (League Average)			Stage 3 (League Average + 1SD)			Attacker		
	Slow	Medium	Fast	Slow	Medium	Fast	Slow	Medium	Fast	*Slow*	*Medium*	*Fast*
	23	**13**	**7**	**51**	**28**	**17**	**79**	**43**	**27**	0-6m/sec	6-12m/sec	>12m/sec
Clearance	0	0	0	0	0	0	0	0	0	0.1%	0.7%	0.9%
Corner Cross	0	0	0	0	0	1	0	0	1	0.0%	0.0%	2.2%
Corner Pass	0	0	0	0	0	0	0	0	0	0.0%	0.1%	0.2%
Cross	0	0	1	0	0	2	0	0	3	0.0%	0.6%	8.7%
Direct Free Kick Cross	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.5%
Direct Free Kick Pass	0	0	0	0	0	0	0	0	0	0.1%	0.3%	1.0%
Direct Free Kick Shot	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.5%
Goal Kick	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.1%
Goalkeeper Kick	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Indirect Free Kick Pass	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Pass	2	7	4	4	15	10	6	23	16	7.6%	52.9%	58.2%
Penalty	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.2%
Shot	0	0	1	0	0	2	0	1	4	0.1%	0.9%	13.6%
Touch	21	6	1	47	13	2	73	19	4	92.1%	44.5%	13.8%

Left Midfield

	Stage 1 (League Average - 1SD)			Stage 2 (League Average)			Stage 3 (League Average + 1SD)			Left Midfield		
	Slow	Medium	Fast	Slow	Medium	Fast	Slow	Medium	Fast	*Slow*	*Medium*	*Fast*
	36	**20**	**12**	**68**	**36**	**24**	**100**	**52**	**36**	0-6m/sec	6-12m/sec	>12m/sec
Clearance	0	0	0	0	1	1	0	1	1	0.1%	1.3%	1.8%
Corner Cross	0	0	1	0	0	1	0	0	1	0.0%	0.1%	3.7%
Corner Pass	0	0	0	0	0	0	0	0	0	0.0%	0.2%	0.3%
Cross	0	0	1	0	0	2	0	0	4	0.0%	0.5%	9.8%
Direct Free Kick Cross	0	0	0	0	0	0	0	0	1	0.0%	0.0%	1.0%
Direct Free Kick Pass	0	0	0	0	0	1	0	0	1	0.1%	0.5%	1.5%
Direct Free Kick Shot	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.4%
Goal Kick	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Goalkeeper Kick	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Indirect Free Kick Pass	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Pass	2	11	8	4	19	15	6	27	22	6.0%	52.2%	61.8%
Penalty	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.1%
Shot	0	0	1	0	0	2	0	0	3	0.0%	0.2%	7.2%
Touch	34	9	2	64	16	3	94	24	5	93.7%	45.1%	12.6%

Central Midfield

	Stage 1 (League Average - 1SD)			Stage 2 (League Average)			Stage 3 (League Average + 1SD)			Central Midfield		
	Slow	Medium	Fast	Slow	Medium	Fast	Slow	Medium	Fast	*Slow*	*Medium*	*Fast*
	30	**22**	**14**	**61**	**37**	**27**	**92**	**52**	**40**	0-6m/sec	6-12m/sec	>12m/sec
Clearance	0	1	0	0	1	1	0	1	1	0.2%	1.6%	1.9%
Corner Cross	0	0	1	0	0	1	0	0	1	0.0%	0.0%	3.2%
Corner Pass	0	0	0	0	0	0	0	0	0	0.0%	0.1%	0.1%
Cross	0	0	1	0	0	1	0	0	1	0.0%	0.3%	3.3%
Direct Free Kick Cross	0	0	0	0	0	0	0	0	1	0.0%	0.0%	1.0%
Direct Free Kick Pass	0	0	1	0	1	1	0	1	1	0.2%	1.4%	3.3%
Direct Free Kick Shot	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.4%
Goal Kick	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Goalkeeper Kick	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Indirect Free Kick Pass	0	0	0	0	0	0	0	0	0	0.0%	0.1%	0.1%
Pass	2	14	11	4	24	21	6	34	30	6.3%	64.7%	75.7%
Penalty	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.1%
Shot	0	0	1	0	0	1	0	0	2	0.0%	0.2%	4.0%
Touch	28	7	1	57	12	2	86	17	3	93.3%	31.6%	6.9%

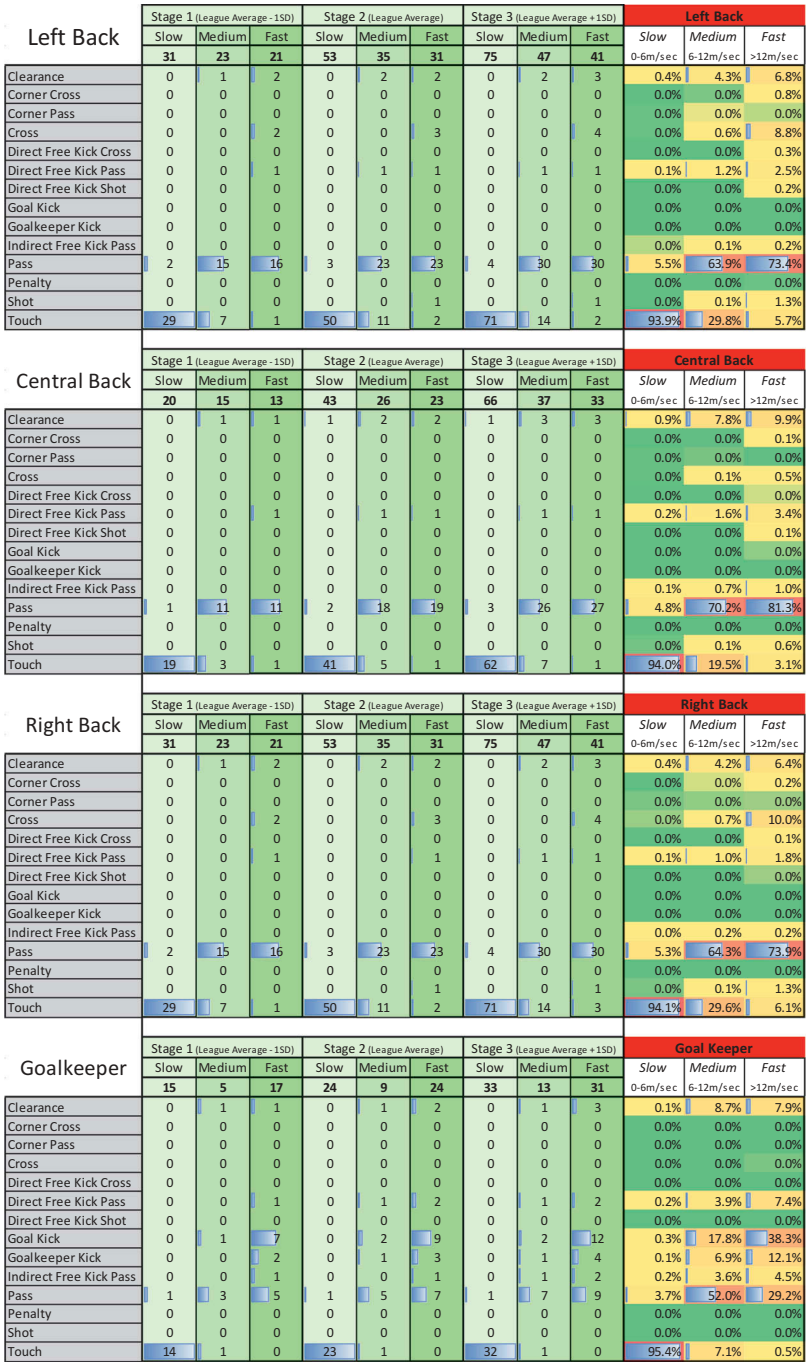
Right Midfield

	Stage 1 (League Average - 1SD)			Stage 2 (League Average)			Stage 3 (League Average + 1SD)			Right Midfield		
	Slow	Medium	Fast	Slow	Medium	Fast	Slow	Medium	Fast	*Slow*	*Medium*	*Fast*
	33	**20**	**12**	**65**	**35**	**24**	**97**	**50**	**36**	0-6m/sec	6-12m/sec	>12m/sec
Clearance	0	0	0	0	1	1	0	1	1	0.1%	1.2%	2.0%
Corner Cross	0	0	1	0	0	1	0	0	1	0.0%	0.0%	3.7%
Corner Pass	0	0	0	0	0	0	0	0	0	0.0%	0.1%	0.1%
Cross	0	0	2	0	0	3	0	1	5	0.0%	0.8%	12.8%
Direct Free Kick Cross	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.9%
Direct Free Kick Pass	0	0	0	0	0	1	0	0	1	0.1%	0.5%	1.6%
Direct Free Kick Shot	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.1%
Goal Kick	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Goalkeeper Kick	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Indirect Free Kick Pass	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Pass	2	10	7	4	18	15	6	26	22	6.0%	51.3%	60.3%
Penalty	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Shot	0	0	1	0	0	2	0	0	2	0.0%	0.3%	6.1%
Touch	31	9	2	61	16	3	91	23	5	93.7%	45.7%	12.3%

Figure 3. Data-based, position-specific, interval kicking programme. The right-most columns represent the percentages of kicks made in a game for each position, and each type of kick. The central portion of the figure depicts the three stages of the interval kicking programme. For each player position, 3 example stages are provided representing the league average number of kicks (stage 2), 1 standard deviation less and more (stages 1 and 3, respectively). The top row represents the total number of kicks in each category, at each of these stages. Below this are the number of the individual kick types performed by the individual starting positions. The conditional formatting (blue colored) data bars represent proportional column totals for each position.

Discussion

To implement an appropriate kicking rehabilitation programme for return to match play after an injury the actual kicking loads a player is exposed to during a game need to be understood. To our knowledge, this is the first investigation to quantify the kicking loads undertaken by professional soccer players. In this study actual game data for a full season of the Major League Soccer (MLS) is described for kicking load for both distance and velocity for different playing positions and different kicking actions. While 14 different kicking actions are described, the distributions of kicking types are seen to be highly skewed towards touches and then passes. We suggest that kicking



Left Back

	Stage 1 (League Average - 1SD)			Stage 2 (League Average)			Stage 3 (League Average + 1SD)			Left Back		
	Slow	Medium	Fast	Slow	Medium	Fast	Slow	Medium	Fast	*Slow*	*Medium*	*Fast*
	31	**23**	**21**	**53**	**35**	**31**	**75**	**47**	**41**	0-6m/sec	6-12m/sec	>12m/sec
Clearance	0	1	2	0	2	2	0	2	3	0.4%	4.3%	6.8%
Corner Cross	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.8%
Corner Pass	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Cross	0	0	2	0	0	3	0	0	4	0.0%	0.6%	8.8%
Direct Free Kick Cross	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.3%
Direct Free Kick Pass	0	0	1	0	1	1	0	1	1	0.1%	1.2%	2.5%
Direct Free Kick Shot	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.2%
Goal Kick	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Goalkeeper Kick	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Indirect Free Kick Pass	0	0	0	0	0	0	0	0	0	0.0%	0.1%	0.2%
Pass	2	15	16	3	23	23	4	30	30	5.5%	63.9%	73.4%
Penalty	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Shot	0	0	0	0	0	1	0	0	1	0.0%	0.1%	1.3%
Touch	29	7	1	50	11	2	71	14	2	93.9%	29.8%	5.7%

Central Back

	Stage 1 (League Average - 1SD)			Stage 2 (League Average)			Stage 3 (League Average + 1SD)			Central Back		
	Slow	Medium	Fast	Slow	Medium	Fast	Slow	Medium	Fast	*Slow*	*Medium*	*Fast*
	20	**15**	**13**	**43**	**26**	**23**	**66**	**37**	**33**	0-6m/sec	6-12m/sec	>12m/sec
Clearance	0	1	1	1	2	2	1	3	3	0.9%	7.8%	9.9%
Corner Cross	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.1%
Corner Pass	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Cross	0	0	0	0	0	0	0	0	0	0.0%	0.1%	0.5%
Direct Free Kick Cross	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Direct Free Kick Pass	0	0	1	0	1	1	0	1	1	0.2%	1.6%	3.4%
Direct Free Kick Shot	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.1%
Goal Kick	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Goalkeeper Kick	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Indirect Free Kick Pass	0	0	0	0	0	0	0	0	0	0.1%	0.7%	1.0%
Pass	1	11	11	2	18	19	3	26	27	4.8%	70.2%	81.3%
Penalty	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Shot	0	0	0	0	0	0	0	0	0	0.0%	0.1%	0.6%
Touch	19	3	1	41	5	1	62	7	1	94.0%	19.5%	3.1%

Right Back

	Stage 1 (League Average - 1SD)			Stage 2 (League Average)			Stage 3 (League Average + 1SD)			Right Back		
	Slow	Medium	Fast	Slow	Medium	Fast	Slow	Medium	Fast	*Slow*	*Medium*	*Fast*
	31	**23**	**21**	**53**	**35**	**31**	**75**	**47**	**41**	0-6m/sec	6-12m/sec	>12m/sec
Clearance	0	1	2	0	2	2	0	2	3	0.4%	4.2%	6.4%
Corner Cross	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.2%
Corner Pass	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Cross	0	0	2	0	0	3	0	0	4	0.0%	0.7%	10.0%
Direct Free Kick Cross	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.1%
Direct Free Kick Pass	0	0	1	0	0	1	0	1	1	0.1%	1.0%	1.8%
Direct Free Kick Shot	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Goal Kick	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Goalkeeper Kick	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Indirect Free Kick Pass	0	0	0	0	0	0	0	0	0	0.0%	0.2%	0.2%
Pass	2	15	16	3	23	23	4	30	30	5.3%	64.3%	73.9%
Penalty	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Shot	0	0	0	0	0	1	0	0	1	0.0%	0.1%	1.3%
Touch	29	7	1	50	11	2	71	14	3	94.1%	29.6%	6.1%

Goalkeeper

	Stage 1 (League Average - 1SD)			Stage 2 (League Average)			Stage 3 (League Average + 1SD)			Goal Keeper		
	Slow	Medium	Fast	Slow	Medium	Fast	Slow	Medium	Fast	*Slow*	*Medium*	*Fast*
	15	**5**	**17**	**24**	**9**	**24**	**33**	**13**	**31**	0-6m/sec	6-12m/sec	>12m/sec
Clearance	0	1	1	0	1	2	0	1	3	0.1%	8.7%	7.9%
Corner Cross	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Corner Pass	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Cross	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Direct Free Kick Cross	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Direct Free Kick Pass	0	0	1	0	1	2	0	1	2	0.2%	3.9%	7.4%
Direct Free Kick Shot	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Goal Kick	0	1	7	0	2	9	0	2	12	0.3%	17.8%	38.3%
Goalkeeper Kick	0	0	2	0	1	3	0	1	4	0.1%	6.9%	12.1%
Indirect Free Kick Pass	0	0	1	0	0	1	0	1	2	0.2%	3.6%	4.5%
Pass	1	3	5	1	5	7	1	7	9	3.7%	52.0%	29.2%
Penalty	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Shot	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Touch	14	1	0	23	1	0	32	1	0	95.4%	7.1%	0.5%

Figure 3. (Continued).

load is described most meaningfully with a velocity analysis and have provided a criteria-based return to play kicking programme.

It can be seen from these results that contrary to Arundale et al. (2015) there are meaningful kicking load differences in the volume, intensity, and types of kicking action performed by different playing positions with the exception of the left and right backs. We suggest that these should be reflected in the preparation and rehabilitation processes. Early examination of the physical demands of soccer considered only total distance ran, whereas subsequent work has drilled deeper considering numbers of high intensity sprints as well as total distances covered at lower speeds, along with the variability of these measures within and between players (Gregson et al. 2010; Bush et al. 2015b). The work here has, perhaps unsurprisingly, documented differences in kicking demands for different playing positions, and we suggest that as with the physical preparation of healthy players and rehabilitation from injury in regard running demands, attention to these normal kicking match demands are necessary.

The variation in the number of kicking events between playing positions, as well as between games are seen to be

Table 3. Pair-wise comparisons for different kick speeds, compared by playing position, per normalized game.

Kick type	Position	Compared to	Mean difference (95% CI for difference [standard error])	*P value*	Kick type	Position	Compared to	Mean difference (95% CI for difference [standard error])	*P-value*	Kick type	Position	Compared to	Mean difference (95% CI for difference [standard error])	*P-value*
Slow	Attacker	Central back	7.9 (5.8 to 9.9 [0.65])	<0.01	Medium	Attacker	Central back	1.7 (-0.3 to 3.8 [0.65])	0.19	Fast	Attacker	Central back	−5.8 (-7.8 to -3.7 [0.65])	<0.01
		Central midfield	−10.7 (−12.6 to −8.9 [0.59])	<0.01			Central midfield	−8.4 (−10.3 to −6.6 [0.59])	<0.01			Central midfield	−10.1 (−11.9 to −8.2 [0.59])	<0.01
		Goalkeeper	25.6 (23.0 to 28.2 [0.83])	<0.01			Goalkeeper	18.6 (16.0 to 21.2 [0.82])	<0.01			Goalkeeper	−7.2 (−9.7 to −4.6 [0.82])	<0.01
		Left back	−4.6 (−7.1 to −2.1 [0.81])	<0.01			Left back	−6.9 (−9.5 to −4.4 [0.80])	<0.01			Left back	−14.9 (−17.4 to −12.4 [0.80])	<0.01
		Left midfield	−17.8 (−20.2 to −15.5 [0.75])	<0.01			Left midfield	−8.5 (−10.9 to −6.2 [0.75])	<0.01			Left midfield	−7.8 (−10.1 to −5.4 [0.75])	<0.01
		Right back	−3.1 (−5.6 to −0.6 [0.81])	<0.01			Right back	−6.8 (−9.3 to −4.3 [0.80])	<0.01			Right back	−14.3 (−16.8 to −11.8 [0.80])	<0.01
		Right midfield	−14.4 (−16.8 to −12.1 [0.75])	<0.01			Right midfield	−7.6 (−9.9 to −5.2 [0.75])	<0.01			Right midfield	−7.7 (−10.1 to −5.4 [0.75])	<0.01
	Central back	Attacker	−7.9 (−9.9 to −5.8 [0.65])	<0.01		Central back	Attacker	−1.7 (−3.8 to 0.3 [0.65])	0.19		Central back	Attacker	5.8 (3.7 to 7.8 [0.65])	<0.01
		Central midfield	−18.6 (−20.6 to −16.7 [0.62])	<0.01			Central midfield	−10.2 (−12.1 to −8.2 [0.62])	<0.01			Central midfield	−4.3 (−6.2 to −2.4 [0.62])	<0.01
		Goalkeeper	17.7 (15.1 to 20.3 [0.84])	<0.01			Goalkeeper	16.9 (14.2 to 19.5 [0.84])	<0.01			Goalkeeper	−1.4 (−4.0 to 1.2 [0.84])	0.94
		Left back	−12.5 (−15.0 to −9.9 [0.82])	<0.01			Left back	−8.7 (−11.2 to −6.1 [0.82])	<0.01			Left back	−9.1 (−11.7 to −6.6 [0.82])	<0.01
		Left midfield	−25.7 (−28.1 to −23.3 [0.77])	<0.01			Left midfield	−10.3 (−12.7 to −7.9 [0.77])	<0.01			Left midfield	−2.0 (−4.4 to 0.4 [0.77])	0.23
		Right back	−11.0 (−13.5 to −8.4 [0.82])	<0.01			Right back	−8.5 (−11.1 to −5.9 [0.82])	<0.01			Right back	−8.6 (−11.1 to −6.0 [0.82])	<0.01
		Right midfield	−22.3 (−24.7 to −19.9 [0.77])	<0.01			Right midfield	−9.3 (−11.7 to −6.9 [0.77])	<0.01			Right midfield	−2.0 (−4.4 to 0.4 [0.77])	0.26
	Central midfield	Attacker	10.7 (8.9 to 12.6 [0.59])	<0.01		Central midfield	Attacker	8.4 (6.6 to 10.3 [0.59])	<0.01		Central midfield	Attacker	10.1 (8.2 to 11.9 [0.59])	<0.01
		Central back	18.6 (16.7 to 20.6 [0.62])	<0.01			Central back	10.2 (8.2 to 12.1 [0.62])	<0.01			Central back	4.3 (2.4 to 6.2 [0.62])	<0.01
		Goalkeeper	36.3 (33.8 to 38.8 [0.80])	<0.01			Goalkeeper	27.0 (24.5 to 29.5 [0.80])	<0.01			Goalkeeper	2.9 (0.4 to 5.4 [0.80])	<0.01
		Left back	6.2 (3.7 to 8.6 [0.78])	<0.01			Left back	1.5 (−0.9 to 3.9 [0.78])	0.79			Left back	−4.8 (−7.3 to −2.4 [0.78])	<0.01
		Left midfield	−7.1 (−9.3 to −4.8 [0.73])	<0.01			Left midfield	−0.1 (−2.4 to 2.2 [0.73])	1.00			Left midfield	2.3 (0.0 to 4.6 [0.73])	0.04
		Right back	7.7 (5.2 to 10.1 [0.78])	<0.01			Right back	1.7 (−0.8 to 4.1 [0.78])	0.59			Right back	−4.3 (−6.7 to −1.8 [0.78])	<0.01
		Right midfield	−3.7 (−5.9 to −1.4 [0.73])	<0.01			Right midfield	0.9 (−1.4 to 3.1 [0.73])	1.00			Right midfield	2.3 (0.1 to 4.6 [0.72])	0.03
	Goalkeeper	Attacker	−25.6 (−28.2 to −23.0 [0.83])	<0.01		Goalkeeper	Attacker	−18.6 (−21.2 to −16.0 [0.82])	<0.01		Goalkeeper	Attacker	7.2 (4.6 to 9.7 [0.82])	<0.01
		Central back	−17.7 (−20.3 to −15.1 [0.84])	<0.01			Central back	−16.9 (−19.5 to −14.2 [0.84])	<0.01			Central back	1.4 (−1.2 to 4.0 [0.84])	0.94
		Central midfield	−36.3 (−38.8 to −33.8 [0.80])	<0.01			Central midfield	−27.0 (−29.5 to −24.5 [0.80])	<0.01			Central midfield	−2.9 (−5.4 to −0.4 [0.80])	<0.01
		Left back	−30.2 (−33.2 to −27.2 [0.96])	<0.01			Left back	−25.5 (−28.5 to −22.6 [0.96])	<0.01			Left back	−7.7 (−10.7 to −4.8 [0.96])	<0.01
		Left midfield	−43.4 (−46.3 to −40.5 [0.92])	<0.01			Left midfield	−27.1 (−30.0 to −24.3 [0.92])	<0.01			Left midfield	−0.6 (−3.5 to 2.2 [0.92])	1.00
		Right back	−28.7 (−31.7 to −25.7 [0.96])	<0.01			Right back	−25.3 (−28.3 to −22.4 [0.96])	<0.01			Right back	−7.2 (−10.2 to −4.2 [0.96])	<0.01
		Right midfield	−40.0 (−42.9 to −37.1 [0.92])	<0.01			Right midfield	−26.1 (−29.0 to −23.3 [0.92])	<0.01			Right midfield	−0.6 (−3.4 to 2.3 [0.92])	1.00
	Left back	Attacker	4.6 (2.1 to 7.1 [0.81])	<0.01		Left back	Attacker	6.9 (4.4 to 9.5 [0.80])	<0.01		Left back	Attacker	14.9 (12.4 to 17.4 [0.80])	<0.01
		Central back	12.5 (9.9 to 15.0 [0.82])	<0.01			Central back	8.7 (6.1 to 11.2 [0.82])	<0.01			Central back	9.1 (6.6 to 11.7 [0.82])	<0.01
		Central midfield	−6.2 (−8.6 to −3.7 [0.78])	<0.01			Central midfield	−1.5 (−3.9 to 0.9 [0.78])	0.79			Central midfield	4.8 (2.4 to 7.3 [0.78])	<0.01
		Goalkeeper	30.2 (27.2 to 33.2 [0.96])	<0.01			Goalkeeper	25.5 (22.6 to 28.5 [0.96])	<0.01			Goalkeeper	7.7 (4.8 to 10.7 [0.96])	<0.01
		Left midfield	−13.2 (−16.0 to −10.4 [0.90])	<0.01			Left midfield	−1.6 (−4.4 to 1.2 [0.90])	0.89			Left midfield	7.1 (4.3 to 9.9 [0.90])	<0.01

(*Continued*)

Table 3. (Continued).

Kick type	Position	Compared to	Mean difference (95% CI for difference [standard error])	*P* value	Kick type	Position	Compared to	Mean difference (95% CI for difference [standard error])	*P*-value	Kick type	Position	Compared to	Mean difference (95% CI for difference [standard error])	*P*-value
		Right back	1.5 (−1.4 to 4.4 [0.94])	0.96			Right back	0.2 (−2.7 to 3.1 [0.94])	1.00			Right back	0.6 (−2.4 to 3.5 [0.94])	1.00
		Right midfield	−9.8 (−12.6 to −7.0 [0.90])	<0.01			Right midfield	−0.6 (−3.4 to 2.2 [0.90])	1.00			Right midfield	7.2 (4.4 to 10.0 [0.90])	<0.01
	Left midfield	Attacker	17.8 (15.5 to 20.2 [0.75])	<0.01		Left midfield	Attacker	8.5 (6.2 to 10.9 [0.75])	<0.01		Left midfield	Attacker	7.8 (5.4 to 10.1 [0.75])	<0.01
		Central back	25.7 (23.3 to 28.1 [0.77])	<0.01			Central back	10.3 (7.9 to 12.7 [0.77])	<0.01			Central back	2.0 (−0.4 to 4.4 [0.77])	0.23
		Central midfield	7.1 (4.8 to 9.3 [0.73])	<0.01			Central midfield	0.1 (−2.2 to 2.4 [0.73])	1.00			Central midfield	−2.3 (−4.6 to 0.0 [0.73])	0.04
		Goalkeeper	43.4 (40.5 to 46.3 [0.92])	<0.01			Goalkeeper	27.1 (24.3 to 30.0 [0.92])	<0.01			Goalkeeper	0.6 (−2.2 to 3.5 [0.92])	1.00
		Left back	13.2 (10.4 to 16.0 [0.90])	<0.01			Left back	1.6 (−1.2 to 4.4 [0.90])	0.89			Left back	−7.1 (−9.9 to −4.3 [0.90])	<0.01
		Right back	14.7 (11.9 to 17.5 [0.90])	<0.01			Right back	1.8 (−1.0 to 4.6 [0.90])	0.75			Right back	−6.6 (−9.4 to −3.8 [0.90])	<0.01
		Right midfield	3.4 (0.7 to 6.0 [0.85])	<0.01			Right midfield	1.0 (−1.7 to 3.6 [0.85])	1.00			Right midfield	0.1 (−2.6 to 2.7 [0.85])	1.00
	Right back	Attacker	3.1 (0.6 to 5.6 [0.81])	<0.01		Right back	Attacker	6.8 (4.3 to 9.3 [0.80])	<0.01		Right back	Attacker	14.3 (11.8 to 16.8 [0.80])	<0.01
		Central back	11.0 (8.4 to 13.5 [0.82])	<0.01			Central back	8.5 (5.9 to 11.1 [0.82])	<0.01			Central back	8.6 (6.0 to 11.1 [0.82])	<0.01
		Central midfield	−7.7 (−10.1 to −5.2 [0.78])	<0.01			Central midfield	−1.7 (−4.1 to 0.8 [0.78])	0.59			Central midfield	4.3 (1.8 to 6.7 [0.78])	<0.01
		Goalkeeper	28.7 (25.7 to 31.7 [0.96])	<0.01			Goalkeeper	25.3 (22.4 to 28.3 [0.96])	<0.01			Goalkeeper	7.2 (4.2 to 10.2 [0.96])	<0.01
		Left back	−1.5 (−4.4 to 1.4 [0.94])	0.96			Left back	−0.2 (−3.1 to 2.7 [0.94])	1.00			Left back	−0.6 (−3.5 to 2.4 [0.94])	1.00
		Left midfield	−14.7 (−17.5 to −11.9 [0.90])	<0.01			Left midfield	−1.8 (−4.6 to 1.0 [0.90])	0.75			Left midfield	6.6 (3.8 to 9.4 [0.90])	<0.01
		Right midfield	−11.3 (−14.1 to −8.5 [0.90])	<0.01			Right midfield	−0.8 (−3.6 to 2.0 [0.90])	1.00			Right midfield	6.6 (3.8 to 9.4 [0.90])	<0.01
	Right midfield	Attacker	14.4 (12.1 to 16.8 [0.75])	<0.01		Right midfield	Attacker	7.6 (5.2 to 9.9 [0.75])	<0.01		Right midfield	Attacker	7.7 (5.4 to 10.1 [0.75])	<0.01
		Central back	22.3 (19.9 to 24.7 [0.77])	<0.01			Central back	9.3 (6.9 to 11.7 [0.77])	<0.01			Central back	2.0 (−0.4 to 4.4 [0.77])	0.26
		Central midfield	3.7 (1.4 to 5.9 [0.73])	<0.01			Central midfield	−0.9 (−3.1 to 1.4 [0.73])	1.00			Central midfield	−2.3 (−4.6 to −0.1 [0.72])	0.03
		Goalkeeper	40.0 (37.1 to 42.9 [0.92])	<0.01			Goalkeeper	26.1 (23.3 to 29.0 [0.92])	<0.01			Goalkeeper	0.6 (−2.3 to 3.4 [0.92])	1.00
		Left back	9.8 (7.0 to 12.6 [0.90])	<0.01			Left back	0.6 (−2.2 to 3.4 [0.90])	1.00			Left back	−7.2 (−10.0 to −4.4 [0.90])	<0.01
		Left midfield	−3.4 (−6.0 to −0.7 [0.85])	<0.01			Left midfield	−1.0 (−3.6 to 1.7 [0.85])	1.00			Left midfield	−0.1 (−2.7 to 2.6 [0.85])	1.00
		Right back	11.3 (8.5 to 14.1 [0.90])	<0.01			Right back	0.8 (−2.0 to 3.6 [0.90])	1.00			Right back	−6.6 (−9.4 to −3.8 [0.90])	<0.01

Mean differences are presented along with 95% confidence interval for individual differences, and the associated standard error. Sidak correction for multiple comparisons used in calculation of the associated *P*-value.

large. For example, the average for goal keepers, in an average game would be less than 60 kicks, and more than 120 for midfielders. Similarly, the difference for a midfielder between a game that involved 1 SD less than the average number of kicks and a game that required 1 SD above the average number of kicks would be approximately 70 kicks – from 30 kicks up to 100 kicks. We suggest that both the absolute values as well as the variability in kicking load need to be considered in rehabilitation and preparation strategies.

Using these data, we have modified our return to play strategy for kicking related injuries. Our proposed return to kicking protocol was created as a three-stage protocol where the middle stage is the average kicking match load, and the stages before and after represent 1 SD below and above respectively, that is each step in terms of number of kicks is 1 more SD. We suggest that using this data, at the final stage, players can be assumed to have demonstrated the ability to perform approximately 67% of the maximum kicking loads encountered by their position during a full game (i.e., the match average + 1 SD). If a more conservative return to play is clinically warranted, we suggest adding a fourth stage (average values + 2 SD, approximately 95% of the maximum kicking load) or even a fifth (average + 3 SD, approximately 99% of the load).

n practice, using a velocity-based kicking programme requires more athlete education than a simple distance-based programme. To estimate kicking velocity, athletes need to first experience kicking at velocities matching the individual stages. Practically, this can be achieved by having the athletes kick the ball such that it travels a prescribed distance in two seconds. For the "slow" phase, the ball should travel approximately 6 m (between 1 and 12 m), for the "medium" phase the ball should travel approximately 18 m (12–24 m), and for the "fast" category, the ball needs to travel more than 24 m in 2 s. It is our experience that soccer players are readily able to achieve this with a short period of feedback, and this can be performed in a group situation as part of a regular warm-up.

Conclusion

Professional football players were seen to have varying kicking load volume during match play according to their starting position (with the only exception being left and right backs). Informed by this, we present a data-based interval kicking programme suitable for preparation and rehabilitation purposes tailored to individual positions. There is a substantial difference in the kicking loads required by different playing positions, and between different games. Differences also exist between playing position in regard types of kicks required, we suggest that appropriate preparation and rehabilitation will include attention to these differences.

Key points

Findings

Information for an entire season of the US MLS has been analyzed and with this information position-specific data are described regarding kicking loads experienced during soccer. Further, a data-based interval kicking programme suitable for preparation and rehabilitation purposes is derived from this information

Implications

Loading programmes for preparation and rehabilitation need to consider match requirements of kicking, and these are seen to vary according to playing position. Kicking loads need to be described in terms of volume (simple count) as well as intensity (kicking velocity).

Caution

This data is likely to be league- and team specific. Different leagues around the world need to be analyzed for any variations on these data. The data presented here are for professional adult males. It is unknown if similar loads will be documented in adolescent, female, or amateur players. Similarly different team formations will have different kicking load volumes for separate playing positions (Bradley et al. 2011a). Further, we expect that game situations and playing styles will likely also change kicking load: for example, if the team is more dominant in a game the defenders and forwards from opposite teams will have different kicking loads. Future research could also be useful looking at different types of injuries for different playing positions and examine whether this is reflected in game loads.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

No financial support was provided for this research.

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