

Influence of Tactical Formation on Average and Peak Demands of Elite Soccer Match-Play

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ABSTRACT

Global Positioning Systems (GPS) have provided practitioners with information on the physical activity profiles, such as distance covered, high speed running, and sprint speeds, of team-sport players. However, to date, there is no available literature identifying the average or peak physical demands of elite soccer in the USA. This investigation aims to quantify the activity profiles and most demanding passages of elite soccer competition within different positions, periods, and tactical formations. Activity profiles were captured from 449 whole-period, and 661 peak-period data from 24 field players, from one club, across a 31-game Major League Soccer season. Total distance covered (metres), average speed ($\text{m}\cdot\text{min}^{-1}$), and number of acceleration and deceleration ($\text{m}\cdot\text{s}^{-2}$) efforts were used to comprise whole-period profiles. Peak values for speed ($\text{m}\cdot\text{min}^{-1}$) were obtained by using a moving-average approach for durations lasting 1, 2, 3, 5, and 10 minutes. Across all positions the 4-2-3-1, 3-4-3, and 4-3-3 formations showed a decrease in average speed between the first and second halves (ES [range] = 0.10 – 2.91). The 4-3-1-2 yielded greatest whole-period accelerations and decelerations for full backs (ES [range] = 0.09 – 2.63), and overall distance covered and average speed for strikers (ES [range] = 0.39 – 2.57). Most peak intensities were observed in the first half of match-play, with attacking midfielders and strikers demonstrating their greatest activity during the first half of a 4-3-

1-2 formation. Altering tactical formations results in different physical outputs for all positional groups. Depending on the formation implemented, positional groups resulted in differences, with physical outputs, between halves during match-play.

Keywords: match analysis, acceleration, global positioning systems, speed, physical performance.

INTRODUCTION

The use of global positioning systems (GPS) has become a staple in monitoring external loads of field-based sports (26). Understanding the activity profiles of match-play can provide coaches and practitioners with information to guide preparation strategies for competition (3). Activity profiles have been investigated in all levels of soccer competition, ranging from youth to professional (7). To the best of the authors' knowledge, despite the introduction of the Major League Soccer (MLS) in 1996, no such data has been published in relation to the MLS to date. More recently, activity profiles (obtained via GPS) have been investigated throughout professional soccer matches to determine positional differences, as well as differences between the first and second half (28). Decrements in running intensities have been associated with fatigue when following a short-term intense period, start of the second half, and/or towards the end of the match (20). However, when technical-tactical parameters remain consistent,

differences in running intensities between halves can be useful indicators of fatigue (14).

Reductions in average speed and number of accelerations between periods of play (e.g., from the first to second half) may provide an indication of fatigue (3). However, given the high metabolic cost of accelerating and the high neuromuscular cost of decelerating, perhaps the high intensity acceleration and deceleration outputs ($>3\text{m}\cdot\text{s}^{-2}$) may be more indicative of fatigue (22). For example, in Australian Football, decreases in maximal accelerations throughout match-play are thought to indicate the onset of fatigue (2). Recently, researchers have suggested that the variations in match activity profiles could be due to multiple factors, including mental and physical fatigue, pacing strategies, and changes in tactical roles (1, 23). Despite calls for further research on the influence of different tactical formations on activity profiles, to date research is limited (1). Of the research comparing activity profiles among different playing formations, no study has compared the activity profiles of different playing positions across the course of a game and while using different playing formations (27). Therefore, it is unclear whether first to second half differences in activity profiles are due to changes that occur across the course of match-play, or rather, due to variations in tactical formation.

Sparks et al., used a 5-minute time-rolling strategy to investigate the variations in high-intensity running in semi-professional soccer players (25). The authors showed that first-half activity profiles had an impact on second-half outputs, as well as the recovery rate after the most intense 5-minute period of play, suggesting that decrements in running intensities across moving time frames may be caused by the onset of fatigue. More recently, a novel method of quantifying the peak running intensity of competition has been used with researchers establishing the maximal values for moving averages of different duration (9). This method quantifies the peak running intensity of the athlete, for a chosen GPS variable, over 1 to 10-minute rolling periods. Soccer (12), rugby league (8), rugby union (11), Australian Football (10), lacrosse (5), and hurling (30) have all been investigated using this moving average duration method. The results from these studies highlight the peak intensities to which athletes may be exposed throughout match-play, allowing coaches to prescribe 'game-like' drills for a specific time frame. Recently, this method has been used to compare the most demanding passages of play across the first and second half of match-play, as

well as make positional comparisons (6, 18). Further analysis of contextual factors, such as formational differences, using this novel method may uncover some other indicators of fatigue (4).

To the authors' knowledge, there is no available literature identifying the average or peak physical demands of elite soccer in the USA. Therefore, the purpose of this research is to investigate the influence of tactical formations on average and peak activity profiles in elite soccer competition. Furthermore, we examined if differences existed between halves and positional groups for these activity profiles. We hypothesized that the physical outputs of different playing positions would differ according to the tactical formation employed. Specifically, we hypothesized that tactical formations that allow certain positions greater space, would result in greater physical outputs. For example, a 4-3-1-2 could potentially expose the attacking-midfielder to large spaces, depending on the tactical information provided. It was also hypothesized that peak intensities would vary dependant on period of play and tactical formation.

METHODS

Experimental approach to the problem

This study was conducted using a cohort research design comparing seven positional groups, four tactical formations, and between the first and second half of match-play. Global Positioning Systems (GPS) game-data for twenty-four male outfield soccer players, participating in the 2018 Major League Soccer (MLS) season, were collected to analyze the influence of tactical formations on physical performance.

Subjects

Twenty-four male outfield soccer players were monitored during match-play via Global Positioning Systems (GPS) (Apex 10 Hz, STATSport, Northern Ireland). These participants were part of a soccer club, participating in the Major League Soccer (MLS) 2018 season. The data collection was part of the club's sports performance department's monitoring protocol. The study was approved by Australian Catholic University Human Research Ethics Committee (Ethics Register Number: 2018-297E).

Procedures

Each player wore the same microtechnology device across the entirety of their season to minimize interunit variability. The MLS season is comprised of thirty-four regular season games. For this study, three of the games were omitted due to player ejection and/or inability to collect valid data due to indoor stadiums. Therefore, data from thirty-one recorded league games were obtained. Files from players who completed a full 90-minute game, were collected for whole period analysis. Formations were assigned prior to collection and cross-referenced with an online football analysis database (WyScout, Chiavari, Italy). Games that were labelled with >60% of total time played using a pre-determined formation were used for analysis. Only players who completed >75 minutes of match-play were used for peak-period analysis. Data were sorted by playing position (centre-back, full-back, defensive midfielders, attacking midfielder, central midfielder, winger, and striker), tactical formation (4-3-1-2 vs. 4-2-3-1 vs. 4-3-3- vs. 3-4-3), and period of play (first and second half). After categorization and omitting data, a total of 449 (for whole-period) and 611 (for peak-period) files were used in the analysis. The metrics collected from the GPS units included total time, total distance covered (metres), average speed ($\text{m}\cdot\text{min}^{-1}$), and number of acceleration and deceleration efforts ($\text{m}\cdot\text{s}^{-2}$). Peak intensities over specified durations (1 to 10-minute rolling averages) were calculated using relative speed ($\text{m}\cdot\text{min}^{-1}$). The maximum value for each peak intensity variable (relative speed) was used to calculate each of the 5 moving averages. A comparative analysis was performed for each of the collected GPS variables for each period of play, as well as each tactical formation used.

Statistical analysis

Multiple linear mixed models were assembled in order to examine differences between formation and periods of play. Standardized differences with interpretation of change determined by effect size (ES) and their associated 90% CI were assessed, with thresholds set as: <0.20, trivial; 0.21-0.60, small; 0.61-1.20, moderate; 1.21-2.0, large; and >2.0, very large (16). Pairwise comparisons were made, provided by the least squares mean test, in order to analyze differences between groups (15). Differences were considered substantial if they were determined at least likely (>75% likelihood of change) of exceeding the smallest worthwhile difference (SWD; calculated as 0.2 x the between-subject

standard deviation (SD)) (16). All statistical analyses were performed using a customized spreadsheet (Microsoft Excel; Microsoft, Redmond, USA), and the R statistical software (R.3.3, R foundation for Statistical Computing).

RESULTS

Table 1 shows the match activity profiles for the seven positions, grouped periods of play (first and second half) as well as the four tactical formations used throughout the season.

Whole Game Demands

Centre backs had greater activity profiles in the first half compared to the second half, for all whole-period metrics, in the 4-2-3-1 formation (Distance; ES = 0.39; 0.11 – 0.67, Speed; ES = 0.94; 0.65 – 1.23, Accelerations; ES = 0.40; 0.11 – 0.68, Decelerations; ES = 0.45; 0.13 – 0.77). Similarly, Strikers covered more distance in the first half, in all formations played, compared to the second half (4-3-1-2; ES = 0.73; 0.04 – 1.43, 4-2-3-1; ES = 0.82; 0.53 – 0.82, 4-3-3; ES = 0.78; 0.08 – 1.63, 3-4-3; ES = 1.04; 0.36 – 1.72). When playing in the 4-2-3-1 formation, defensive midfielders (ES = 0.51; 0.17 – 0.85) and wingers (ES = 0.36; 0.02 – 0.71) covered slightly more distance in the first half than the second half of match-play. All positions displayed a greater average speed in the first half than the second half in 4-2-3-1, 3-4-3, and 4-3-3 formations (ES range = 0.42 – 1.69; 90% CI 0.02 – 5.03).

The acceleration and deceleration profiles for full backs were greater in the 4-3-1-2 formation than all other formations (ES range = 0.65 – 1.05; -0.26 – 1.96). The average speed in the first half, for defensive midfielders playing in the 4-3-3 formation was greater than all other formations (vs 4-2-3-1; ES = 0.73; -0.19 – 1.65, vs 3-4-3; ES = 0.85; -0.04 – 1.73). Distance covered and average speed for attacking midfielders were greater in both the 4-3-1-2 and 4-2-3-1 formations, for both halves, compared to the 3-4-3 formation (ES range = 0.77 – 1.85; 0.03 – 6.95). Similarly, strikers covered greater overall distance at a higher average speed, in both halves, in the 4-3-1-2 formation, than the 4-2-3-1 and 4-3-3 formations (ES range = 0.62 – 1.44; -0.85 – 3.44).

Table 1. Match activity profiles of different positions and formations during an elite men's soccer season (mean ± SD).

Formation	Variable	CB		FB		DM		CM		AM		WG		ST	
		1 st Half	2 nd Half	1 st Half	2 nd Half	1 st Half	2 nd Half	1 st Half	2 nd Half	1 st Half	2 nd Half	1 st Half	2 nd Half	1 st Half	2 nd Half
4-2-3-1 (n=17)	Distance (m)	4834 ± 352 #	4694 ± 374	5190 ± 280	5144 ± 351	5693 ± 342 #	5514 ± 393			5797 ± 171 #c	5703 ± 253 c	5342 ± 364 #	5155 ± 390	4665 ± 291 #	4411 ± 234
	Speed (m·min ⁻¹)	102 ± 7.1 #	95 ± 7.9	110 ± 5.7 #	104 ± 6.7	120 ± 6.9 #	112 ± 7.2			122 ± 4.0 #c	115 ± 5.7 c	112 ± 6.4 #c	104 ± 8.0	98 ± 5.6 #	89 ± 4.7 b
	Accelerations (n°)	32 ± 7 #	30 ± 6	30 ± 10	29 ± 11	31 ± 11	30 ± 6			24 ± 8 #	18 ± 7	30 ± 10 #	24 ± 9	31 ± 8 #b	26 ± 7
	Decelerations (n°)	36 ± 8 #	32 ± 7	40 ± 11 #	37 ± 12	43 ± 13 #	38 ± 7			29 ± 11 #	22 ± 8	37 ± 14 #	30 ± 11	36 ± 10	33 ± 8
3-4-3 (n=6)	Distance (m)	4740 ± 257	4796 ± 426			5758 ± 293	5815 ± 357 d			5318 ± 227	5293 ± 392	5224 ± 249	5084 ± 432	4746 ± 268 #	4396 ± 342
	Speed (m·min ⁻¹)	98 ± 6.1 #	95 ± 9.0			119 ± 6.6 #	116 ± 8.3			110 ± 5.6 #	105 ± 9.1	108 ± 6.1 #	103 ± 6.1	99 ± 7.7 #	89 ± 8.1 b
	Accelerations (n°)	32 ± 5	31 ± 9			33 ± 11 #	29 ± 7			25 ± 11 #	19 ± 4	38 ± 12 #bd	31 ± 13 bd	32 ± 4 #b	26 ± 6
	Decelerations (n°)	38 ± 9	37 ± 9 b			45 ± 7 d	42 ± 9			29 ± 9 #	21 ± 6	44 ± 12 #d	37 ± 13 b	39 ± 6 #	33 ± 8
4-3-3 (n=5)	Distance (m)	4766 ± 274	4758 ± 239	5081 ± 396	5098 ± 243	5835 ± 124 c	5814 ± 530	5506 ± 384	5510 ± 301			5450 ± 277 c	5473 ± 245 cd	4571 ± 222 #	4334 ± 114
	Speed (m·min ⁻¹)	102 ± 5.7 #c	93 ± 5.4	108 ± 9.1 #	100 ± 6.3	125 ± 4.0 #cd	114 ± 14.0	118 ± 9.4 #	109 ± 7.9			116 ± 6.0 #c	108 ± 7.4 c	98 ± 5.9 #	84 ± 5.0
	Accelerations (n°)	33 ± 4	30 ± 10	31 ± 9	28 ± 10	34 ± 6	33 ± 9	26 ± 4	28 ± 10			24 ± 12	21 ± 6	22 ± 3	23 ± 4
	Decelerations (n°)	35 ± 6 #	32 ± 8	35 ± 11	36 ± 11	42 ± 4	41 ± 13	47 ± 3	45 ± 9			41 ± 10 #	29 ± 11	33 ± 8	31 ± 10
4-3-1-2 (n=3)	Distance (m)	5075 ± 300 #bd	4916 ± 309 d	5207 ± 208	5107 ± 260			5662 ± 158	5665 ± 286	5889 ± 399 c	5691 ± 64 c			5145 ± 456 #bd	4558 ± 189bd
	Speed (m·min ⁻¹)	104 ± 4.4 #	100 ± 8.1 b	108 ± 3.6 #	103 ± 6.6 b			116 ± 5.4	115 ± 3.7 b	124 ± 8.7 c	117 ± 4.9 c			109 ± 9.8 #bd	95 ± 6.6 bd
	Accelerations (n°)	33 ± 5	33 ± 5	44 ± 12 bd	44 ± 15 bd			31 ± 7 b	31 ± 4	22 ± 7	20 ± 4			29 ± 13	37 ± 6 bd
	Decelerations (n°)	36 ± 4	35 ± 4	51 ± 14 bd	52 ± 15 bd			49 ± 11 #	42 ± 5	28 ± 9	30 ± 4 cd			35 ± 20	31 ± 7

^a = greater than 4-3-1-2 counterpart, ^b = greater than 4-3-3 counterpart, ^c = greater than 3-4-3 counterpart, ^d = greater than 4-2-3-1 counterpart, ^e = greater than 1st half, # = greater than 2nd half. CB = Centre back, FB = Full back, DM = Defensive midfielder, CM = Central midfielder, AM = Attacking midfielder, WG = Winger, ST = Striker. All observed differences are >75% likelihood of being greater than the smallest worthwhile change (calculated as 0.2 x between-subject SD).

Table 2. Peak running intensities, displayed in $\text{m}\cdot\text{min}^{-1}$, of different positions and formations during an elite men's soccer season (mean \pm SD).

Formation	Moving average duration	CB		FB		DM		CM		AM		WG		ST	
		1 st Half	2 nd Half	1 st Half	2 nd Half	1 st Half	2 nd Half	1 st Half	2 nd Half	1 st Half	2 nd Half	1 st Half	2 nd Half	1 st Half	2 nd Half
4-2-3-1 (n=17)	1	176 $\pm 13.1^c$	173 ± 16.7	198 $\pm 14.8^\#$	190 ± 21.9	203 $\pm 14.9^\#$	194 ± 17.7			199 ± 8.3	199 $\pm 12.1^c$	199 $\pm 13.4^\#$	185 ± 17.9	174 $\pm 13.3^\#$	167 $\pm 19.2^b$
	2	148 $\pm 8.2^\#$	143 ± 14.8	164 $\pm 11.0^\#$	159 $\pm 13.7^b$	173 $\pm 11.3^\#$	165 ± 13.3			175 $\pm 7.7^{c\#}$	171 $\pm 8.3^c$	169 $\pm 13.6^\#$	156 ± 12.3	147 $\pm 7.8^\#$	139 $\pm 13.2^b$
	3	139 $\pm 7.1^\#$	134 ± 12.7	154 $\pm 9.1^{b\#}$	147 ± 12.2	162 $\pm 9.4^\#$	155 ± 12.2			164 $\pm 7.6^{c\#}$	159 $\pm 6.5^c$	158 $\pm 11.6^{c\#}$	144 ± 12.1	139 $\pm 8.9^\#$	127 ± 12.8
	5	130 $\pm 9.5^\#$	122 ± 10.8	142 $\pm 7.9^{b\#}$	137 $\pm 12.3^b$	153 $\pm 8.1^\#$	144 ± 12.6			153 $\pm 8.6^{c\#}$	148 $\pm 8.9^c$	146 $\pm 11.6^{c\#}$	134 ± 12.7	129 $\pm 9.0^\#$	116 ± 11.9
	10	119 $\pm 8.6^\#$	111 ± 8.8	128 ± 7.7	125 $\pm 10.9^b$	140 $\pm 8.2^\#$	130 ± 10.9			139 $\pm 5.4^{c\#}$	136 $\pm 7.7^c$	133 $\pm 8.9^\#$	122 ± 11.1	117 $\pm 9.0^\#$	106 ± 9.2
3-4-3 (n=6)	1	170 ± 10.1	182 $\pm 27.8^{b\$}$			199 ± 18.1	202 $\pm 13.8^d$			197 ± 14.9	192 ± 11.2	196 ± 15.0	194 $\pm 16.7^d$	171 ± 20.9	171 $\pm 16.8^b$
	2	147 ± 9.4	152 $\pm 15.3^{bd\$}$			174 ± 10.0	174 $\pm 9.1^d$			167 $\pm 11.1^\#$	161 ± 14.5	165 ± 13.1	165 $\pm 13.6^d$	144 ± 15.3	142 $\pm 14.0^b$
	3	136 ± 8.9	139 $\pm 12.4^b$			163 ± 11.0	164 $\pm 10.4^d$			158 $\pm 10.8^\#$	150 ± 10.2	152 ± 12.2	152 $\pm 10.7^d$	135 ± 18.5	130 $\pm 14.2^b$
	5	129 ± 8.6	127 $\pm 12.5^{bd}$			150 ± 12.0	150 $\pm 11.2^d$			147 $\pm 9.1^\#$	136 ± 9.1	142 ± 9.7	139 $\pm 9.5^d$	129 ± 15.7	119 ± 12.3
	10	117 $\pm 8.6^\#$	113 ± 11.0			138 ± 9.5	138 $\pm 5.7^d$			136 $\pm 7.3^\#$	125 ± 7.5	130 ± 9.4	124 ± 11.1	117 $\pm 12.3^\#$	107 ± 9.0

4-3-3 (n=5)	1	179 ± 15.1 ^{c#}	170 ± 13.2	192 ± 21.9	184 ± 13.9	205 ± 16.0	203 ± 16.4 ^d	198 ± 12.3 [#]	190 ± 13.4	201 ± 15.2 [#]	194 ± 9.8 ^d	188 ± 18.0 ^{cd#}	157 ± 13.4
	2	152 ± 12.9 ^{c#}	145 ± 8.6	159 ± 15.5	153 ± 6.5	181 ± 12.5 ^{cd#}	170 ± 9.7	171 ± 12.8	167 ± 11.8	172 ± 8.3 ^{c#}	161 ± 4.8 ^d	154 ± 15.4 ^{c#}	129 ± 6.8
	3	145 ± 10.4 ^{cd#}	133 ± 9.1	149 ± 11.4 [#]	144 ± 8.1	172 ± 9.5 ^{cd#}	160 ± 10.6	160 ± 14.3	154 ± 11.2	161 ± 7.1 ^{c#}	147 ± 5.5	143 ± 15.0 [#]	122 ± 8.0
	5	133 ± 6.5 ^{c#}	121 ± 9.1	137 ± 9.2 [#]	132 ± 7.0	162 ± 7.1 ^{cd#}	151 ± 7.5 ^d	152 ± 15.3	145 ± 10.7	150 ± 8.0 ^{c#}	141 ± 4.9 ^d	132 ± 13.5 [#]	113 ± 9.8
	10	119 ± 5.5 [#]	109 ± 6.5	128 ± 8.8 [#]	117 ± 8.3	146 ± 6.4 ^{cd#}	136 ± 11.4 ^d	137 ± 12.3 [#]	129 ± 13.2	136 ± 9.0 ^{c#}	126 ± 7.4 ^d	117 ± 9.3 [#]	103 ± 7.3
4-3-1-2 (n=3)	1	178 ± 8.8 ^c	186 ± 8.6 ^{bd\$}	199 ± 10.8	197 ± 9.4 ^{bd}			206 ± 7.2 ^b	210 ± 9.3 ^{b\$}	221 ± 9.2 ^{cd#}	207 ± 5.1 ^{cd}	187 ± 16.0 ^{cd#}	173 ± 18.4 ^b
	2	157 ± 13.1 ^{cd}	161 ± 16.5 ^{bcd}	167 ± 8.4 ^b	169 ± 16.2 ^{bd}			176 ± 7.2	175 ± 3.6 ^b	188 ± 16.8 ^{cd#}	170 ± 1.0 ^c	168 ± 19.1 ^{bcd#}	150 ± 17.4 ^{bd}
	3	145 ± 12.4 ^{cd}	153 ± 14.9 ^{bcd\$}	157 ± 7.5 ^b	154 ± 12.7 ^{bd}			166 ± 10.4	164 ± 7.6 ^b	178 ± 18.2 ^{cd#}	158 ± 9.6 ^c	158 ± 19.7 ^{bcd#}	137 ± 11.9 ^{bd}
	5	135 ± 9.0 ^{cd}	142 ± 14.2 ^{bcd\$}	145 ± 7.7 ^b	140 ± 11.9 ^b			156 ± 7.5 [#]	152 ± 5.3 ^b	168 ± 15.3 ^{cd#}	146 ± 11.4 ^c	141 ± 14.5 ^{cd#}	126 ± 14.0 ^{bd}
	10	127 ± 11.9 ^{bcd}	123 ± 10.7 ^{bcd}	133 ± 5.0 ^{bd#}	126 ± 10.9 ^b			142 ± 5.9 [#]	138 ± 6.7 ^b	150 ± 5.1 ^{cd#}	133 ± 8.2 ^c	128 ± 8.0 ^{bcd#}	113 ± 11.7 ^{bd}

^a = greater than 4-3-1-2 counterpart, ^b = greater than 4-3-3 counterpart, ^c = greater than 3-4-3 counterpart, ^d = greater than 4-2-3-1 counterpart, ^{\$} = greater than 1st half, [#] = greater than 2nd half. CB = Centre back, FB = Full back, DM = Defensive midfielder, CM = Central midfielder, AM = Attacking midfielder, WG = Winger, ST = Striker. All observed differences are >75% likelihood of being greater than the smallest worthwhile change (calculated as 0.2 x between-subject SD).

Peak Demands

When comparing peak intensities (across 1, 2, 3, 5, and 10-minute periods), wingers and strikers both had greater outputs, in the first half than the second half in the 4-3-3 and 4-2-3-1 formations (ES range = 0.46 – 1.82; 0.04 – 2.64). Furthermore, in the 4-3-3 formation, centre backs demonstrated greater intensities, across all moving averages in the first half compared to the second half (ES range = 0.52 – 1.64; 0.11 – 2.20) (Figure 1). Attacking midfielders also had greater first half outputs, for all moving averages, compared to the second half, in the 4-3-1-2 formation (ES range = 0.61 – 1.89; 0.36 – 2.38). In the 4-3-1-2 formation, the first half peak intensity for strikers were greater than both the 3-4-3 (ES range = 0.75 – 1.15; -0.12 – 2.01) and 4-2-3-1 (ES range = 0.69 – 1.19; 0.02 – 1.71) formations. In the 4-3-1-2 formation, centre backs and attacking midfielders had greater peak intensities across all first half averages, compared to the 3-4-3 formation (ES range = 0.63 – 1.71; 0.05 – 2.60). Defensive midfielders had greater second half peak intensities in the 3-4-3 formation compared to the 4-2-3-1 formation (ES range = 0.46 – 1.44; 0.02 – 2.17). Conversely, in the 4-3-1-2 formation, centre backs had a greater second half peak intensity in the 1, 3, and 5-minute

moving averages (ES range = 0.50 – 0.71; 0.07 – 1.51). Furthermore, centre backs also had greater second half peak intensities, compared to the first half, in the 1 and 2-minute moving averages, when playing in a 3-4-3 formation (1-minute; ES = 1.07; 0.17 – 2.30, 2-minute; ES = 0.59; 0.14 – 1.31).

DISCUSSION

This study investigated the activity profiles and peak intensities throughout different tactical formations, from one club, across a regular Major League Soccer (MLS) season. We compared activity profiles for different positions in multiple tactical formations, periods of play, and exercise bout duration. To the authors' knowledge, this is the first study to document the activity profiles of MLS match-play using GPS technology. Although previous researchers have indicated the importance of playing position and formation on activity profiles (27), this study is the first to identify and categorize peak physical output according to periods of play, playing position and tactical formation. Our major original finding is the differences in activity profiles between periods of play and playing formations. Furthermore, these findings demonstrate that all playing positions

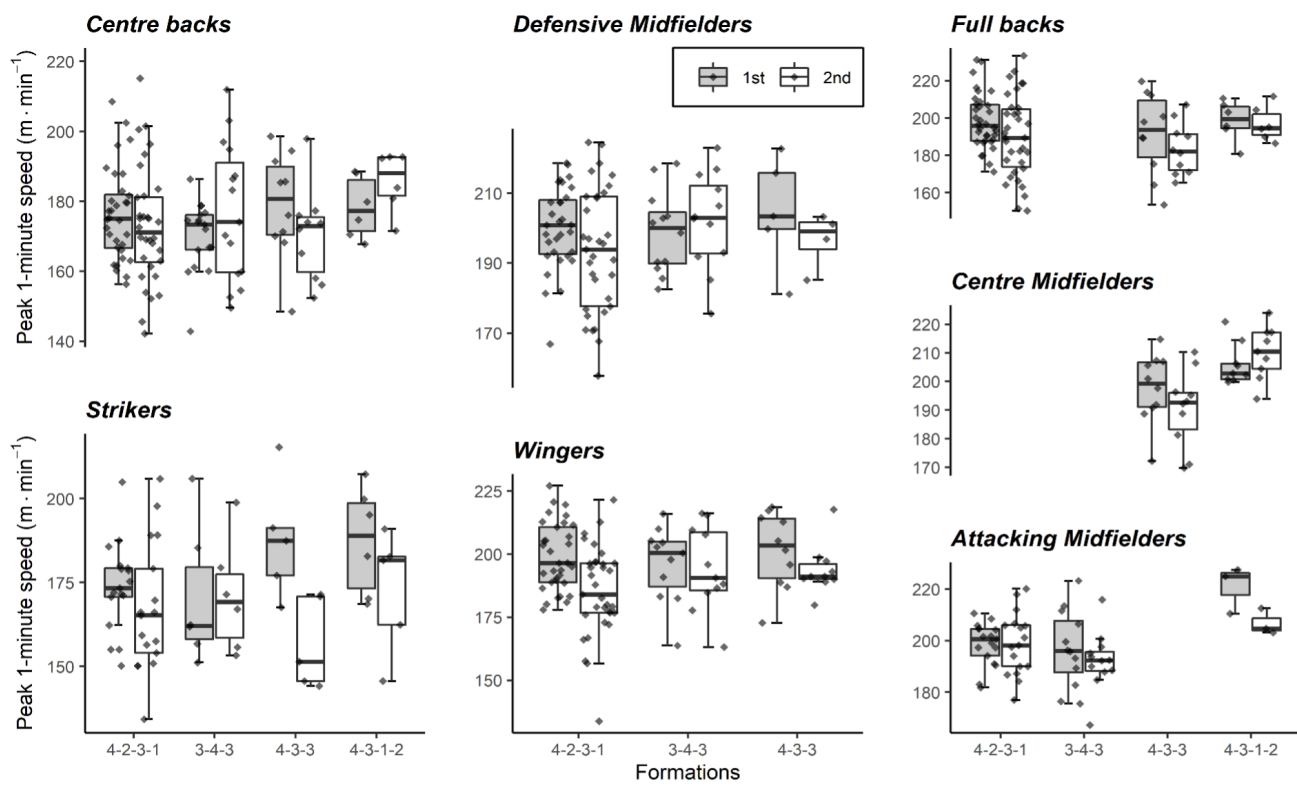


Figure 1. Boxplots, including individual data points, of 1-minute peak intensities for all positions during a variety of tactical formations in men's elite soccer competition. The box plot represents the median, interquartile ranges and 90% confidence limits of the group values. (n=607).

exhibited a decrement in peak running intensity as the duration of the exercise interval increased.

Consistent with the findings from other soccer research, there were notable decrements in physical outputs over the course of the match (13, 19). In the current investigation, the 4-2-3-1 formation showed the greatest between-period differences in that centre-backs, attacking midfielders and wingers all had greater first-half activity profiles for distance covered, speed, accelerations, and decelerations (Table 1). Furthermore, wingers and strikers showed greater peak intensities, for all time frames, in the first half compared to second half in the 4-2-3-1 formation (Figure 1). The decrease in running profiles during match-play has previously been suggested as evidence of the onset of fatigue (23, 29). However, the possibility of other contextual factors (e.g. pacing, match scoreline) being associated with the decrease in physical outputs warrants consideration (2, 4). Although the reductions in whole-period physical outputs could indicate the onset of fatigue, there may be less notable differences when comparing shorter periods of duration (6). Specifically, the current findings demonstrated reductions in peak intensities, for each position, between 2-5 minutes duration from the first to second half, in the 4-2-3-1 formation. However, these results suggest that players who are exposed to greater peak intensities and whole-period outputs in the first half, may have an increased likelihood of reductions in peak intensities and whole-period outputs in the second half.

The results from the present study indicate that variations in physical outputs can occur due to a myriad of factors including playing position, tactical formation and period of play. Previous literature has identified how variance in activity profiles is dependent on position, tactical formation, coaching strategies and physical qualities (1, 17, 27). Some peak-intensity markers showed reductions from the first to second half, with no statistical differences observed between the first and second half in whole-period comparisons. For example, centre-backs playing in a 4-3-1-2 formation demonstrated the highest peak-intensities in the second half of play (from minutes 2-10) compared to all other formations (Table 2). Additionally, the 4-3-1-2 tactical formation yielded some of the greatest peak physical outputs compared to other formations, with centre backs, attacking midfielders and strikers demonstrating the greatest peak intensities. However, in the whole-period analysis, statistical differences were only noted for total distance and average speed, when

comparing the 4-3-1-2 formation to the 4-2-3-1. It is plausible that playing in the 4-3-1-2 formation yielded more defensive transitions, resulting in greater physical activity for centre-backs. It is also possible that the most demanding passages of play occurred in the second half due to small match scoreline margins.

While differences in activity profiles were observed across different tactical formations, we acknowledge that multiple factors could influence these findings. To provide a holistic approach to match-play analysis, the current study examined more variables than previous research (18, 27, 28). When examining the current results, wingers playing in the 4-2-3-1 formation showed greater whole-period outputs for total distance, average speed, accelerations, and decelerations in the first half, compared to the second. Furthermore, wingers experienced reductions in peak-running intensities from the first to the second half in the 4-2-3-1 formation. It has previously been suggested that due to the great levels of metabolic power required to produce high-magnitude acceleration and decelerations, notable changes in these variables could be indicative of fatigue (22). However, variables such as scoreline margins and tactical demands need to be considered to appropriately interpret the onset of fatigue (4, 21). Additional limitations may include the absence of training load leading into the monitored games, as well as other contextual factors (e.g., difficulty of opponent and/or venue) within the analyzed matches (24). Furthermore, it is acknowledged that tactical formations are dynamic and team shape and/or tactics vary throughout match-play, which could potentially alter the peak physical outputs between halves. The finding of reductions in physical outputs across the most demanding passages of play as well as whole-periods suggest that either fatigue, pacing, or tactical influences influence match activity profiles in wingers (4).

PRACTICAL APPLICATIONS

The results from this study highlight the overall activity profiles and most demanding periods of play in the MLS. Examination of peak intensities in conjunction with whole-period analysis can provide practitioners with a greater insight into potential onsets of fatigue or pacing strategies during elite soccer match-play. Although this cohort only consisted of one team, across one season, our results show that peak-intensities across moving average durations (for both halves) showed the greatest sensitivity. We would

suggest using this type of analysis (peak intensities throughout different variables) in conjunction with whole-period analysis when examining potential onsets of fatigue or pacing strategies during match-play. Having individual activity profiles categorized by position, period of play, and formation, can allow practitioners to prescribe training at, or exceeding, “game-like” intensity. Efficient game-speed training, when prescribed appropriately, may postpone the onset of fatigue during match play.

These practical applications may include:

- Coaches manipulating variables in small-sided games to illicit greater physical responses. For example, expanding the dimensions of a 4v4 drill will likely increase the opportunity for players to gain exposure to greater speeds ($m \cdot s^{-1}$) comparative to match-speed.
- Identifying a consistent pattern in decrements of whole-period outputs and peak intensities between periods of play may inform coaching staff to examine future weekly training plans to potentially delay the onset of fatigue.
- Prescribing appropriate work:rest ratios for specific drills to ensure the desired physical adaptation occurs. For example, allowing appropriate rest for a small-sided game can increase the likelihood of repeating the most-demanding passage of match-play.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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