〈研究論文〉

Ball possession influences the activity profile during competitive matches among male soccer players at the university level

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Abstract

In this paper, we aimed to comprehensively investigate the impact of ball possession on the activity profiles of university soccer players at different competitive levels. The participants in this study were first-team (competition league) 30 outfield players and second-team (training league) 30 outfield players from a team. The first-team and second-team players belong to the same university soccer team. We evaluated performance in 11 ball possession training sessions and 11 competitive matches. Physical performance data (running demands and heart rate response) were collected using global positioning system technology and short-range radio telemetry. Technical performance, expressed as ball possession, was evaluated using notational analysis. Total distance, high-intensity running (HIR), and heart rate response were significantly changed between different competitive levels. HIR times and HIR percentage time were significantly different in the team own half or the opponent's half. The ball possession percentage was also significantly different and it showed a strong correlation with deceleration times. Our results suggest that the influence of ball possession percentage varies the appearance in own half or opponent's half required for HIA times and the number of decelerations. These findings would serve as the reference when select the training and tactics for ball possession.

Keywords: Association football, Match analysis, Match performance, Time-motion analysis, Notational analysis

1. Introduction

Soccer is a highly complex sport where performance relies on the interplay between physical and technical factors[9]. Many researchers have explored individual physical[15] and technical factors during match-play[13], but few studies have performed a more holistic evaluation of soccer performance[6]. In soccer, the most popular technical parameter is ball possession, which is a strong predictor of success[20)22)23)]. However, this relationship is highly complex, because passing efficiency (e.g., ratio of passes to shots on goal) and offensive strategy (e.g., direct attack vs. counterattack) are also important for success[13)24)]. Previous studies primarily focused on the determinants of ball possession rather than on the physical indicators reflecting ball possession[21)23)]. This approach fails to account for the complex, dynamic nature of soccer, wherein physical and technical factors interact[31)35)]. A mixed approach is required, in which ball possession is evaluated in the context of both physical and technical activity profiles[9)].

The physical demands of elite match play have substantially increased in the last decade[8)]. Although there is no exact measure of physical performance in elite matches, the total distance covered, primarily

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while high-intensity running (HIR), may represent a useful measure of performance[32]. Currently, global positioning system (GPS) technology is widely used for evaluating physical performance in team sports, providing quantitative data on speed, duration, and distance characterising locomotor patterns throughout the match[28]. When studying physical performance during match play, locomotion is often categorized based on movement speed, resulting in categories such as standing, sprinting, acceleration, or deceleration[5)7)39)]. In addition, previous research has been conducted on the temporal patterns of acceleration and deceleration during the match-play. In particular, it has described pointed out that deceleration may affect performance due to the physical load involved[5)]. Mohr et al. (2003)[32)] reported that HIR distance is longer for top-level players than for moderate-level players. However, previous studies did not investigate the importance of technical factors on HIR parameters during elite matches.

Heart rate (HR) is a good indicator of exercise intensity and can be used to quantify physical performance during matches[2)29)]. Although it is expected that HR differences will reflect the variability of HIR parameters during ball possession and retention among players of the team controlling the match, the magnitude of this effect should be clarified. Bradley et al. (2013)[9)] suggested that ball possession does not influence the team's overall activity profile but does impact HIR efforts and technical performance elements.

Traditionally, investigations into the passing behaviours of elite soccer athletes have employed notational analysis focused on variables such as pass frequency or pass streak, and their correlation with game performance[17)19)]. Notational analysis is applied to clarify the relationship of performance with various technical parameters[37)]. Reep and Benjamin (1968)[36)], who were the first to systematically study passing behaviour in elite soccer athletes, collected data from 3213 matches played between 1953 and 1963 and reported two major findings: (i) nearly 80% of goals were scored after three or fewer successive passes, and (ii) one goal was scored for every 10 shots. More recently, Hughes and Franks (2005)[18)] proposed a standardized method for counting successive passes and re-examined the correlation between shots and goals, which revealed that successful teams attempted shots after a greater number of successive passes and achieved more goals per possession during ''possession play'' (longer passing sequences, more ball contact) than during ''direct play'' (shorter passing sequences, less ball contact). To facilitate adequate evaluation of player and team performance, both ball possession and positional data should be considered. Notational analysis of ball possession data helps quantify interactions between the players in possession of the ball and their teammates. Thus, notational analysis may be useful for evaluating technical performance, and the outcomes could serve as feedback for players and as information for their coaches, who may plan better training strategies.

Already, a study has been conducted on the outcome of the English premier league match and the ball possession during the match[20)]. Regardless of the score of the match, it is reported that the winning team has a much higher ball during the match than the losing team. However, it is suggested that this is not due to a specific team strategy, but due to different competitive levels at players. Therefore, it is necessary to consider the effect on the ball possession due to differences in the player's competitive levels. Therefore, depending on the competitive levels of the same team, more specific knowledge can be presented by examining the relationship between ball possession activity profiles during competitive matches and training in detail.

Our goal was to comprehensively investigate the impact of ball possession on activity profiles of university soccer players at different competitive levels. For this purpose, we enrolled players from the competition league (first-team) and training league (second-team) of the same university, and compared ball possession activity profiles during training and competitive matches. We hypothesized that ball possession activity profiles would be better for first-team than for second-team players. This is because physical demand increases as the level of competition increases and is therefore considered proportional to physical demand during the match. The outcomes of this research should be useful to

coaches and team staff, who may take these findings into consideration when planning physical and technical training sessions.

2. Methods

2.1. Participants

The participants in this study were 30 first-team outfield players from a team registered in the 2017 Kanto University League division 1 (competition league; first-team), and 30 second-team outfield players from a team registered in the 2017 Kanto University Independence League division 2 (training league; second-team). The first-team and second-team players belong to the same university soccer team. The Independence League is a training league for university soccer players in Japan. In addition, the first-team included 3 outfield players in Universiade Japan National Team and one outfield player in the under-20 Japan National Team. The physical characteristics of participants are shown in Table 1 for both teams. Both teams held training sessions five times a week during the measurement period. All training sessions were approximately 2 hours, and a fitness-based session was conducted once or twice each week. The remainder of the training sessions comprised technical and tactical training. The fitness-based sessions involved a mixture of endurance and/or sprint training. All participants were aware of the study methods, procedures, and risks, and signed an informed consent document before participating in the study. This study was conducted according to the Declaration of Helsinki and was approved by our university's Ethics Committee for Human Experiments.

2.2. Experimental design

Both the first-team and the second-team teams had ball possession training sessions and competitive matches measured 11 times (i.e., competition league 11 matches for the first-team and training league 11 matches for the second-team). In the matches, data of matches lasting more than 80 minutes were extracted. The number of samples obtained was 99 (i.e., central defenders; 25, wide defenders; 23, central midfielders; 21, wide midfielders; 17 and forwards; 13) for the first-team and 101 (i.e., central defenders; 24, wide defenders; 23, central midfielders; 20, wide midfielders; 18 and forwards; 16) for the second-team. No player was sent off in any of the measured matches. The outline is shown in Figure 1. The ball possession training sessions were conducted 5 times, with a trial time of 90 seconds and a set of intervals of 30 seconds as one set at 30 m × 15 m size 30 minutes before the start of the match. Ten outfield players participated, 4 versus 4, plus 2 floaters who played with the team in possession of the ball (Figure 2). The standard matches lasted for two equal periods of 45 minutes each, plus any additional overtime when necessary. The halftime interval was 15 minutes. Matches were played on artificial turf and natural grass pitches measuring 105 m × 68 m (length × width) in either case, which conforms to the official soccer rules. Goals of 2.44 m × 7.32 m × 1.9 m (height × width × depth) and official balls were used during the matches. Both the first- and second-team teams used a traditional

Table 1 Physical characteristics of the study participants

Variables	First team players	Second team players	Effect size
Age (years)	20.0 ± 0.8	20.1 ± 1.0	0.1
Height (cm)	174.8 ± 5.2	176.3 ± 3.8	0.3
Body weight (kg)	68.0 ± 6.3	67.7 ± 4.5	0.1
Skeletal muscle mass (kg)	34.3 ± 3.2	34.2 ± 2.6	0.0
Body fat (%)	11.7 ± 2.5	11.8 ± 2.5	0.0
Body mass index ($kg \cdot m^{-2}$)	22.2 ± 1.3	21.8 ± 1.6	1.8

The participants were selected from among outfield players of the first (competition league; first team) and second (training league; second team) soccer divisions of the same university. Mean values ± SD of 30 of players (n = 30) are shown.

	Ball possession training sessions (warm-up before competition match)	Competition matches
Number of measurements	- Training sessions measured 11 times ✓ *First team 11times / Second team 11 times*	- Competition matches measured 11 times ✓ *First team 11times / Second team 11 times*
Data collection	- Physical performance • *Running demands* • *Heart rate response*	- Physical performance • *Running demands* • *Heart rate response* - Technical performance • *Ball possession*
Number of samples by competitive levels	- First team players (n=30) ; Ten outfield players were selected every 11 matches (including training sessions) ✓ *Total 99 samples (central defenders; 25, wide defenders; 23, central midfielders; 21, wide midfielders; 17 and forwards; 13)* - Second team players (n=30) ; Ten outfield players were selected every 11 matches (including training sessions) ✓ *Total 101 samples (central defenders; 24, wide defenders; 23, central midfielders; 20, wide midfielders; 18 and forwards; 16)*	
Outcomes	- Table 2	- Table 3, Table 4, Table 5, Table 6

Figure 1. The outline shows the number of measurements, data collection, number of samples by competitive levels and outcomes for ball possession training sessions and competition matches.

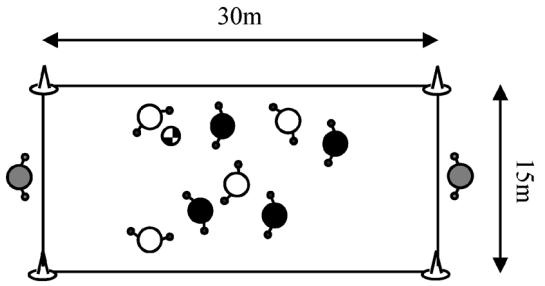

Figure 2. Ball possession training. These training sessions were conducted as four (light pictograms) versus four (dark pictograms) outfield players, plus two floaters (grey pictograms).

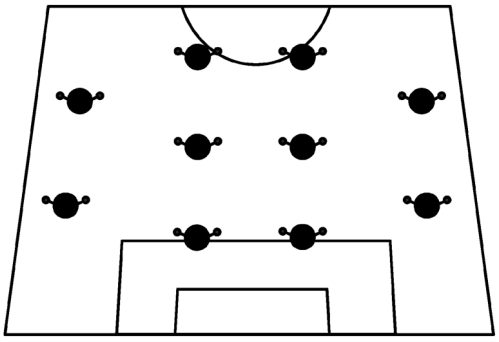

Figure 3. Playing formation. The 4–4–2 playing formation consisted of four defenders (two central defenders and two wide defenders), four midfielders (two central midfielders and two wide midfielders), and two forwards.

rigid playing system 4–4–2 (Figure 3). Both teams' ball possession training sessions and the matches were led by the same coaching staff and used tactics based on possession.

2.3. Time-motion analysis to evaluate physical performance

2.3.1. Data collection

Physical performance was evaluated in terms of running distance and speed data, which were collected using 15 Hz GPS units (SPI–HPU; GPSports Systems, Canberra, Australia) placed on each player's upper back, inside a pocket sewn into the undershirt. The validity and reliability of such measurements were reported previously[4]. After each training session and match, the recorded data were exported to dedicated software (Team AMS; GPSports Systems, Canberra, Australia) for motion analysis.

2.3.2. Running demands

Player movement speeds were calculated as described previously[7)39)], and locomotion was classified into the following categories: standing (<0.4 km·h^{-1}), walking (0.4–6.0 km·h^{-1}), low-speed running

(6.0–12.0 km·h^{-1}), moderate-speed running (12.0–18.0 km·h^{-1}), high-speed running (18.0–24.0 km·h^{-1}), and sprinting (≥24.0 km·h^{-1}). HIR was defined as movement speed >18.0 km·h^{-1}. The distances covered at various speeds were summed to determine the total distance covered during each training session and match.

Acceleration and deceleration were calculated as described previously[5] and classified into the following locomotion patterns: low acceleration (Lacc) (1–2 m·s^{-2}), moderate acceleration (Macc) (2–3 m·s^{-2}), high acceleration (Hacc) (>3 m·s^{-2}), low deceleration (Ldec) (1–2 m·s^{-2}), moderate deceleration (Mdec) (2–3 m·s^{-2}), and high deceleration (Hdec) (>3 m·s^{-2}).

2.3.3. Analysis of the distribution of HIR efforts across the playing field

HIR efforts and HIR percent time in each field zone (own half and opponent's half) were obtained using dedicated software (Team AMS; GPSports Systems, Canberra, Australia). HIR efforts across the halfway line were counted for the half in which the effort ended.

2.3.4. Heart rate monitoring

HR responses were recorded using a short-range radio telemetry device (polar T34; Polar Electro, Kempele, Finland). For each player, the maximal HR (HRmax) was estimated as HRmax=220−age[38]. HR zones were defined based on thresholds relative to HRmax[2)29)], as follows: <70%HRmax, 71–80%HRmax, 81–90%HRmax, 91–95%HRmax, and ≥95%HRmax. The percent time spent at HRmax and in each HR zone were reported.

2.4. Notational analysis to evaluate technical performance

2.4.1. Data collection

Video footage of the matches was recorded using two video cameras (HDR–CX420 and HDR–PJ390; Sony, Tokyo, Japan) and analysed to track the movements of individual players. One stationary camera was placed high in the stands, at the level of the halfway line. The other camera was placed behind the goal line to record sideward movements. The validity of collecting data by video camera was reported previously[27].

2.4.2. Data analysis and reliability

All video footage was initially created for compatibility with Final Cut Pro® (version 9.0; Apple, San Francisco, CA, USA) and then converted to Windows Media Video format for further analysis. Ball possessions were recorded on an electronic spreadsheet. Two skilled analysts with over five years of expertise in notational analysis observed each match twice, with approximately one month between the two analyses to avoid the learning effect. The analysts were not directly involved in the study design. Inter-observer agreement was evaluated as Cohen's kappa[12], as described previously[26]. Cohen's kappa statistics ranged from 0.81 to 0.92, with a mean of 0.85, indicating that the measurements were reliable.

2.4.3. Definition of ball possession

Ball possession started when a player gained possession of the ball by any means other than from a player on the same team. The player must have had enough control over the ball to be able to deliberately influence its subsequent direction. Ball possession comprised a series of passes between players on the same team, but ended immediately when one of the following events occurred: a) the ball went out of play, b) the ball touched a player on the opposing team (e.g., by means of a tackle or an intercepted pass), or c) an infringement of the rules takes place (e.g., a player is offside or a foul is committed). Momentary touches that did not significantly change the direction of the ball were excluded[33]. Thus, ball possession was calculated as the proportion of time that a subject's own team held the ball[13]. The ball possession time (sec) and ball possession percentage (i.e., ball possession time /actual playing time×100) were calculated based on competitive matches measured 11 times, data on ball possession training sessions are not included.

2.5. Statistical analysis

Data are presented as means±standard deviations. All calculations were performed using Statistical

Package for Social Sciences (SPSS) version 17.0 (IBM Corp., Chicago, IL, USA). Between-team differences were assessed using the Student paired t-test. Pearson's correlation analysis was used to assess the relationship between ball possession percentage and different performance factors including distance covered and HIR. Absolute standardized effect size was provided to supplement the findings. Statistical significance was set at $p < 0.05$.

3. Results

3.1. Physical performance during ball possession training sessions

The physical performance noted in ball possession training sessions is summarized in Table 2. Compared to second-team players, first-team players covered a significantly shorter total distance (878.8 ± 16.4 vs. 909.6 ± 26.2 m) but higher HIR distance (11.4 ± 0.9 vs. 7.8 ± 0.6 m) (effect size 1.2–1.8, $p < 0.01$ for both comparisons). Distances covered during low-speed running, high-speed running, and sprinting also differed significantly between the two teams (effect size 1.8–1.9, $p < 0.01$ for all comparisons).

The maximum speed was significantly higher (effect size 1.6, $p < 0.01$), whereas the mean speed was significantly lower (effect size 1.8, $p < 0.01$) among first-team players than among second-team players. The number accelerations and decelerations were significantly higher in second-team players than in first-team players for all locomotion patterns analysed (effect size 1.3–1.8, $p < 0.01$ for all comparisons).

The mean HR (148.6 ± 2.7 vs. 159.8 ± 1.6 bpm) and mean percentage time of HRmax ($73.1 \pm 3.5\%$ vs. $79.3 \pm 1.1\%$) were significantly smaller in first-team players than in second-team players (effect size 1.5–1.8, $p < 0.01$ for both comparisons). Additionally, first-team players spent significantly more time in the lower HR zones (<70%HRmax, $28.2 \pm 16.5\%$ vs. $12.8 \pm 12.1\%$; 71–80%HRmax, $44.4 \pm 10.7\%$ vs. $24.8 \pm 14.7\%$; effect size 1.0–1.2, $p < 0.01$ for both comparisons), whereas second-team players spent more time in the higher HR zones (81–90%HRmax, $24.2 \pm 15.5\%$ vs. $44.5 \pm 9.1\%$, $p < 0.05$; 91–95%HRmax, $2.1 \pm 6.2\%$ vs. $15.2 \pm 18.7\%$, $p < 0.01$; effect size 0.9–1.3).

3.2. Physical performance during competitive matches

Table 3 summarizes the physical performance noted in competitive matches. Compared to second-team players, first-team players covered a significantly longer total distance (12012.6 ± 282.3 vs. 10999.0 ± 178.7 m) and HIR distance (1238.9 ± 84.5 vs. 1081.6 ± 115.5 m) (effect size 1.2–1.8, $p < 0.01$ for both comparisons). The distance covered during all activities was higher for the first team than for the second team (effect size 1.1–1.6, $p < 0.01$ for all comparisons).

The two teams did not differ regarding acceleration efforts (effect size 0.6–0.7), but the second team had significantly more deceleration efforts for all locomotion patterns analysed (effect size 0.8–1.2, $p < 0.05$ for all comparisons).

The mean HR (158.4 ± 2.2 vs. 164.4 ± 2.4 bpm) and mean percent time spent at HRmax (78.5 ± 1.1 % vs. 81.5 ± 1.7 %) were significantly higher for second-team players than for first-team players (effect size 1.4–1.6, $p < 0.01$ for both comparisons). Additionally, first-team players spent significantly more time in the <70%HRmax zone ($15.3 \pm 7.7\%$ vs. $7.7 \pm 4.3\%$; effect size 1.1, $p < 0.01$), whereas second-team players spent significantly more time in the 91–95%HRmax zone ($4.4 \pm 5.0\%$ vs. $16.0 \pm 10.9\%$; effect size 1.1, $p < 0.01$).

3.3. Distribution of HIR efforts across the playing field

The distribution of HIR efforts across the playing field is summarized in Table 4. For the first team, 83.2 ± 9.9 and 114.0 ± 25.5 HIR efforts (corresponding to $87.8 \pm 19.6\%$ and $62.8 \pm 13.8\%$ of HIR time) were performed in the team's own half and in the opponent's half of the playing field, respectively; for the second team, these values were 49.1 ± 7.8 and 63.9 ± 10.1 HIR efforts, respectively (corresponding to $50.9 \pm 7.8\%$ and $36.1 \pm 10.1\%$ of HIR time). Own-half values were significantly higher for the

Table 2 Physical performance in ball possession training sessions

Variables	First team	Second team	ES
Distance covered in various locomotion categories			
Standing [velocity <0.4 km·h^{-1}]	0.9 ± 0.2 (m)	0.9 ± 0.1 (m)	0.1
Walking [0.4–6 km·h^{-1}]	340.0 ± 9.0 (m)	343.2 ± 20.1 (m)	0.2
Low-speed running [6–12 km·h^{-1}]	370.6 ± 9.7 (m)	408.8 ± 9.7 (m)**	1.8
Moderate-speed running [12–18 km·h^{-1}]	144.4 ± 6.4 (m)	148.9 ± 7.5 (m)	0.6
High-speed running [18–24 km·h^{-1}]	10.4 ± 0.9 (m)**	7.8 ± 0.6 (m)	1.7
Sprinting [$\geq$24 km·h^{-1}]	1.1 ± 0.2 (m)**	0.0 ± 0.1 (m)	1.9
HIR [$>$18.0 km·h^{-1}]	11.4 ± 0.9 (m)**	7.8 ± 0.6 (m)	1.8
Total	878.8 ± 16.4 (m)	909.6 ± 26.4 (m)**	1.2
Moving speed			
Maximum speed	24.3 ± 0.7 (km·h^{-1})**	22.0 ± 1.0 (km·h^{-1})	1.6
Mean speed	5.2 ± 0.2 (km·h^{-1})	6.8 ± 0.4 (km·h^{-1})**	1.8
Number of acceleration efforts at the following acceleration ranges			
Lacc [acceleration: 1–2 m·s^{-2}]	43.2 ± 3.6 (times)	63.0 ± 4.3 (times)**	1.8
Macc [2–3 m·s^{-2}]	19.2 ± 1.4 (times)	30.0 ± 3.0 (times)**	1.8
Hacc [$>$3 m·s^{-2}]	4.6 ± 0.6 (times)	7.1 ± 1.6 (times)**	1.4
Number of deceleration efforts at the following deceleration ranges			
Ldec [deceleration: 1–2 m·s^{-2}]	37.3 ± 2.5 (times)	45.4 ± 5.8 (times)**	1.3
Mdec [2–3 m·s^{-2}]	14.6 ± 1.9 (times)	22.7 ± 3.2 (times)**	1.7
Hdec [$>$3 m·s^{-2}]	6.8 ± 1.1 (times)	10.5 ± 0.8 (times)**	1.7
HR			
Mean HR	148.6 ± 2.7 (beats·min^{-1})	159.8 ± 1.6 (beats·min^{-1})**	1.8
Mean %HRmax	73.1 ± 3.5 (%)	79.3 ± 1.1 (%)**	1.5
Duration per HR zone			
$<$70%HRmax	28.2 ± 16.5 (%)**	12.8 ± 12.1 (%)	1.0
71–80%HRmax	44.4 ± 10.7 (%)**	24.8 ± 14.7 (%)	1.2
81–90%HRmax	24.2 ± 15.5 (%)	44.5 ± 9.1 (%)**	1.3
91–95%HRmax	2.1 ± 6.2 (%)	15.2 ± 18.7 (%)*	0.9
$\geq$95%HRmax	1.1 ± 3.3 (%)	2.6 ± 5.9 (%)	0.3

The indicated items were assessed during each training session, and mean values ± SD of 11 sessions of players (n = 10) are shown. Every 11 training sessions 10 outfield players were selected from the 30 players by both teams. *$p<0.05$, **$p<0.01$. ES; Effect size, HIR; high-intensity running, Lacc; low acceleration, Macc; moderate acceleration, Hacc; high acceleration, Ldec; low deceleration, Mdec; moderate deceleration, Hdec; high deceleration, HR; heart rate, %HRmax; percentage of maximal HR.

second team (effect size 1.3, $p<0.01$ for HIR efforts and percent time), while opponent's-side values were significantly higher for the first team (effect size 1.2–1.3, $p<0.01$ for both HIR efforts and percent time).

3.4. Technical performance (Ball possession) in competitive matches

Table 5 summarizes the ball possession results. Compared to the second team, the first team had significantly shorter actual playing times (4340.5 ± 161.1 vs. 4462.5 ± 74.9 sec; effect size 0.9, $p<0.01$),

Table 3 Physical performance in competitive matches

Variables	First team	Second team	ES
Distance covered in various locomotion categories			
Standing [velocity <0.4 km·h^{-1}]	5.0 ± 1.1 (m)**	2.7 ± 1.2 (m)	1.4
Walking [0.4–6 km·h^{-1}]	2999.8 ± 70.8 (m)**	2888.3 ± 53.6 (m)	1.3
Low-speed running [6–12 km·h^{-1}]	4787.8 ± 161.5 (m)**	4347.8 ± 166.0 (m)	1.6
Moderate-speed running [12–18 km·h^{-1}]	2981.0 ± 175.2 (m)**	2678.7 ± 149.5 (m)	1.4
High-speed running [18–24 km·h^{-1}]	964.0 ± 72.2 (m)**	865.1 ± 82.4 (m)	1.1
Sprinting [$\geq$24 km·h^{-1}]	274.9 ± 15.0 (m)**	216.5 ± 35.7 (m)	1.5
HIR [$>$18.0 km·h^{-1}]	1238.9 ± 84.5 (m)**	1081.6 ± 115.5 (m)	1.2
Total	12012.6 ± 282.3 (m)**	10999.0 ± 178.7 (m)	1.8
Moving speed			
Maximum speed	34.0 ± 1.1 (km·h^{-1})	33.3 ± 1.3 (km·h^{-1})	0.6
Mean speed	7.3 ± 0.2 (km·h^{-1})	7.5 ± 0.4 (km·h^{-1})	0.7
Number of acceleration efforts at the following acceleration ranges			
Lacc [acceleration: 1–2 m·s^{-2}]	365.9 ± 33.4 (times)	381.6 ± 17.8 (times)	0.6
Macc [2–3 m·s^{-2}]	177.7 ± 23.5 (times)	164.7 ± 15.4 (times)	0.6
Hacc [$>$3 m·s^{-2}]	50.9 ± 10.2 (times)	43.9 ± 8.3 (times)	0.7
Number of deceleration efforts at the following deceleration ranges			
Ldec [deceleration: 1–2 m·s^{-2}]	266.2 ± 17.5 (times)	303.2 ± 30.5 (times)**	1.2
Mdec [2–3 m·s^{-2}]	105.6 ± 11.0 (times)	117.0 ± 13.0 (times)*	0.9
Hdec [$>$3 m·s^{-2}]	65.9 ± 5.2 (times)	71.7 ± 8.7 (times)*	0.8
HR			
Mean HR	158.4 ± 2.2 (beats·min^{-1})	164.4 ± 2.4 (beats·min^{-1})**	1.6
Mean %HRmax	78.5 ± 1.1 (%)	81.5 ± 1.7 (%)**	1.4
Duration per HR zone			
$<$70%HRmax	15.3 ± 7.7 (%)**	7.7 ± 4.3 (%)	1.1
71–80%HRmax	29.6 ± 9.8 (%)	26.6 ± 14.0 (%)	0.3
81–90%HRmax	50.4 ± 13.7 (%)	46.8 ± 13.3 (%)	0.3
91–95%HRmax	4.4 ± 5.0 (%)	16.0 ± 10.9 (%)**	1.1
$\geq$95%HRmax	0.3 ± 0.4 (%)	2.8 ± 4.2 (%)	0.8

The indicated items were assessed during matches and mean values ± SD of 11 matches of players (n = 10) are shown. Every 11 matches 10 outfield players were selected from the 30 players by both teams. *$p<0.05$, **$p<0.01$. ES; Effect size, HIR; high-intensity running, Lacc; low acceleration, Macc; moderate acceleration, Hacc; high acceleration, Ldec; low deceleration, Mdec; moderate deceleration, Hdec; high deceleration, HR; heart rate, %HRmax; percentage of maximal HR.

longer ball possession time (2701.0 ± 191.1 vs. 2305.6 ± 184.0 sec), and higher ball possession percentage (62.3 ± 3.2% vs. 51.6 ± 3.8%) (effect size 1.4–1.7, $p<0.01$ for both ball possession parameters).

3.5. Relationship between technical performance (ball possession) and physical performance

The relationships among physical and technical performance parameters are summarized in Table 6. Significant correlations between physical and technical performance were noted for many variables.

Table 4 Distribution of high-intensity running efforts across the playing field

Variables	First team	Second team	ES
Number of HIR efforts per field zone			
Own half	83.2±9.9(times)	114.0±25.5(times)**	1.3
Opponent's half	87.8±19.6(times)**	62.8±13.8(times)	1.2
Percent HIR time in field zone			
Own half	49.1±7.8(%)	63.9±10.1(%)**	1.3
Opponent's half	50.9±7.8(%)**	36.1±10.1(%)	1.3

The indicated items were assessed during matches and mean values±SD of 11 matches of players (n=10) are shown. For every 11 matches, 10 outfield players were selected from the 30 players available, by both teams. *p<0.05, **p<0.01. ES; Effect size.

Table 5 Technical performance (ball possession) in competitive matches

Variables	First team	Second team	ES
Actual playing time	4340.5±161.1(sec)	4462.5±74.9(sec)**	0.9
Ball possession time	2701.0±191.1(sec)**	2305.6±184.0(sec)	1.4
Ball possession percentage	62.3±3.2(%)**	51.6±3.8(%)	1.7

The indicated items were assessed during matches and mean values±SD of 11 matches of players (n=10) are shown. For every 11 matches 10 outfield players were selected from the 30 players available, by both teams. *p<0.05, **p<0.01. ES; Effect size.

There was a very strong correlation between ball possession percentage and HIR for both the first team ($r=0.90$, $p<0.01$) and the second team ($r=0.95$, $p<0.01$). Additionally, ball possession was strongly correlated with Lacc ($r=0.85$, $p<0.01$), Macc ($r=0.88$, $p<0.01$), and Hacc ($r=0.89$, $p<0.01$) for the first team, whereas only Hacc showed significant correlation for the second team. Deceleration effort was found to be significantly correlated with ball possession at both competitive levels. Finally, ball possession percentage showed a moderate correlation with own-half HIR ($r=0.62$, $p<0.05$) and opponent's-half HIR ($r=0.63$, $p<0.05$) for the first team, and significant correlations with own-half HIR ($r=0.73$, $p<0.01$) and opponent's-half HIR ($r=0.71$, $p<0.01$) for the second team.

4. Discussion

To the best of our knowledge, this is the first study to comprehensively examine ball possession activity profiles during competitive matches among players at different competitive levels on the same team. It is also, to the best of our knowledge, the only study to explore the relationship between ball possession and HIR on own-side and opponent-side fields. Our key findings were: (1) activity profiles, comprising physical and technical performances, were different among players at different competitive levels, and (2) ball possession percentages and deceleration efforts were strongly correlated.

As expected, the first-team surpassed the second-team regarding technical performance (ball possession measurements). However, physical performance parameters including total distance covered and mean speed were significantly higher among second-team players, whereas high-speed running, sprinting, HIR distance, and maximum speed were significantly higher among first-team players. Taken together, these findings suggest that situational control of movement speed yields different results at different competitive levels. Simply put, during ball possessions, increasing

Table 6 Relationships between technical performance and physical performance factors

Variables of PPFs	Correlation coefficient between BPP and each PPF	
	First team	Second team
Distance covered	−0.81**	0.54
Distance at HIR	0.90**	0.95**
Acceleration efforts		
Lacc	0.85**	0.25
Macc	0.88**	0.35
Hacc	0.89**	0.77**
Deceleration efforts		
Ldec	−0.86**	−0.96**
Mdec	−0.87**	−0.96**
Hdec	−0.93**	−0.84**
Mean HR	−0.56	−0.83**
Own half by HIR	−0.62*	−0.73**
Opponent's half by HIR	0.63*	0.71**

Pearson's correlation analysis was performed to assess the relationships between technical performance (i.e. ball possession percentage; BPP) and physical performance factors (PPFs) during 11 matches for both teams. *$p < 0.05$, **$p < 0.01$. HIR; high-intensity running, Lacc; low acceleration, Macc; moderate acceleration, Hacc; high acceleration, Ldec; low deceleration, Mdec; moderate deceleration, Hdec; high deceleration, HR; heart rate, %HRmax; percentage of maximal HR.

movement speed limits the space and time to perform certain movements. Therefore, HIR is required when playing against higher-level opponents[13)15)34)]. In other words, the first-team may have employed superior control of the movement speed during possessions or to regain the ball, even though all acceleration and deceleration measurements indicated that second-team players were at least as physically capable. In small-sided games, the players require a higher level of collective organization and optimization of space occupation[3)]. If these parameters are compromised, acceleration and deceleration may increase to compensate for more frequent loss of possession. In particular, the difference between the teams of acceleration efforts and deceleration efforts in ball possession training sessions is expected to be due to player's competitive levels.

HR is commonly used as a measure of exercise intensity, despite the fact that HR varies in response to many factors[1)]. Interestingly, the mean HR and percent time spent at HRmax were significantly higher among second-team players, indicating that exercise intensity varies with competitive level. The effective duration of ball possession (time per possession) and the time needed to regain possession may affect the exercise intensity required at different competitive levels. Such factors should also be recorded when evaluating technical performance.

We found that, during competitive matches, first-team players covered significantly higher distances in all categories of locomotion, confirming previous observations that higher-level players cover more total distance and HIR distance[11)15)34)]. However, we did not find significant differences in acceleration at different competition levels. Mara et al. (2017)[30)] suggested that acceleration is important to successfully challenge opposing players during ball possessions, defensively tackling opposing players, and getting to the ball first in one-on-one contests. The acceleration analysis results suggest that possession and out-of-possession data should be reported separately. The results of the deceleration

analysis indicated a clear effect of competition level on physical performance. It is expected that more deceleration efforts will be performed when the opposing team has ball possession. Repeated decelerations might increase fatigue because of the rapid eccentric contractions required, which could hinder performance[25]. However, the characteristics of fatigue are muscle specific, and the current understanding of fatigue characteristics of synergistic muscle groups responsible for deceleration is limited[5].

Second-team players had higher HR and spent more time in higher HR zones, likely due to the relationship between ball possession and exercise intensity. When the opposing team has ball possession, the players are required to increase their physical performance regardless of their physical strength. Ball possession is an important technical variable affecting team success[14], and we confirmed that it greatly influences the activity profile. Furthermore, we found that first-team players had significantly higher ball possession percentage and percentage time of HIR in on the opponent's half of the playing field, suggesting that these parameters differ with competitive level, ultimately affecting activity profiles. These findings are supported by the observations of Bradley et al. (2013)[9], which suggested that HIR is important for increasing ball possession percentage. In contrast, factors that increase HIR on the team's own half of the playing field are affected when collective organization and space occupation are inadequate, or during an opponent attack, when the technical skills necessary to gain ball possession become important.

Finally, the relationship between ball possession and noteworthy physical performance became clear. The main findings of this study showed that there is a strong correlation between ball possession percentage and deceleration efforts. When out of possession, it is necessary to move according to the opponent's ball possession, and the number of decelerations increase accordingly (e.g., direct-side change and indirect-side change by the ball possession of the opponent team will be forced to change direction many times). As a result, it is inferred that the player must play with a high exercise intensity. On the contrary, one's own team may have an advantage because it can apply a physical load to the opponent by increasing the ball possessions. Therefore, it is suggested that deceleration may be an index for evaluating ball possession. The information provided in this study would be useful information for coaches since the activity profile is related to ball possession, and observations related to ball possession can help them to select match tactics.

This study has several limitations. In soccer, physical performance is position specific[10][15][16]. However, our analysis of ball possession did not consider each position individually, and instead evaluated the team's overall dynamics. Additionally, match location (home or away), outcome (win, lose, or draw), strength of the opposing team (rank of league), and opposing team's strategy were not included in the current analysis. Further investigations are warranted to clarify the effect of these factors on the activity profile of soccer players. Additionally, it may be useful to evaluate the detailed distribution of HIR efforts across the playing field, including the direction of such efforts. Finally, since we considered only two competitive levels (first and second division) and included players from a single university, our findings may not be fully generalizable.

5. Conclusions

In this study, we employed time-motion analysis and notational analysis to conduct a comprehensive investigation of the influence of ball possession on activity profiles in soccer. We found that the influence of ball possession on activity profile depends on the level of competition, with different levels of HIR occurring in a team's own half and opponent's half fields, and that ball possession percentage correlates with the deceleration effort.

Declaration of interests: The authors declare that there are no conflicts of interests.

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