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Original Article

Match demands in Japanese Division I collegiate men's soccer players

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Abstract:
Problem Statement: Optimal training programs for soccer players are crucial for enhancing performance and preventing injuries. However, understanding the physical demands of matches throughout is essential for designing these programs. **Approach:** Twenty-nine Division 1 collegiate male soccer players were monitored during 15 matches in the 2022 season using global navigation satellite system units at 10 Hz. **Purpose:** This study aimed to examine the influence of position (forwards [FWs], midfielders [MFs], defenders [DFs]), role (starters, non-starters), and the competitive level of opponents (higher-level teams, lower-level teams) on physical demands during official matches. **Results:** Total and relative distances were significantly higher for MFs than for DFs ($p < 0.05$). MFs covered a significantly greater distance than DFs in zone 4 (running: 14.4–19.7 km/h; $p < 0.05$). High-intensity running distance (HIR, > 14.4 km/h) and percentage were greater for MFs than DFs, and maximum acceleration was greater for FWs than for other positions ($p < 0.05$). Starters showed significantly shorter average game time and total running distance ($p < 0.05$). In addition, starters ran significantly less distance in zone 3 (jogging: 7.2–14.3 km/h), zone 4, and zone 5 (high-speed running: 19.8–25.1 km/h) ($p < 0.05$ each). Thus, non-starters ran greater distances in HIR and showed higher percentages in HIR, as well as distances in very high intensity running (VHIR > 19.8 km/h), than starters. No significant differences were seen in maximum speed or maximum acceleration, but non-starters displayed a greater number of accelerations and decelerations than starters ($p < 0.05$). Total distance and relative distance when playing against lower-level teams were significantly greater than when playing against higher-level teams ($p < 0.05$). In addition, running distances in zones 2 and 3 were significantly greater when playing against lower-level teams than when playing against higher-level teams ($p < 0.05$). **Conclusions:** To improve the competitive level of collegiate soccer players in this study, running distance at high intensity or higher needs to be increased. MFs displayed higher total running distance and high-intensity running distance than other positions. Non-starters showed greater high-intensity distance, very high intensity distance, and number of accelerations than starters. Non-starter players played harder than starter players when they played more than 90 minutes as starters. Total distance, relative distance, and low- to moderate-intensity running distance were higher when playing against a lower-level team than against a higher-level team.
Key Words: **college football; global navigation satellite system; GNSS; high-intensity running**

Introduction

Monitoring the external and internal loads placed on athletes during training and competition has become a hot topic in sports science, with sports scientists and coaches attempting to quantify the loads placed on teams and athletes to reduce injury rates and improve performance (Curtis et al., 2018). However, the physical demands of competition need to be understood and considered to provide optimal training programs for athletes and teams. These demands vary across levels of competition (Bangsbo, Mohr, & Krustrup, 2006; Bradley et al., 2009), sex (Krustrup, Mohr, Ellingsgaard, & Bangsbo, 2005; Ramos et al., 2019), age categories (Castagna, D'Ottavio, & Abt, 2003; Curtis et al., 2018; Goto & Saward, 2020), positions in football (Di Salvo et al., 2010; Di Salvo et al., 2007; Di Salvo, Gregson, Atkinson, Tordoff, & Drust, 2009) and team roles (Anderson et al., 2016; Barreira et al., 2022; Castillo-Rodríguez, González-Téllez, Figueiredo, Chinchilla-Minguet, & Onetti-Onetti, 2023).

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Physical demands during matches are also affected by the level of the opponent (Aquino et al., 2021; Folgado, Duarte, Fernandes, & Sampaio, 2014; Lago, Casais, Dominguez, & Sampaio, 2010) and match result (Asian Clemente et al., 2019; Nobari et al., 2021). Folgado et al. (2014) found no difference in total running distance with differences in opponent level, but distance covered during very high intensity running (>19.8 km/h) was significantly higher in matches against higher-level teams. According to Aquino et al. (2021), when comparing higher- and lower-level teams within the same league, higher-level teams showed significantly higher total running distance and high acceleration distance (> 3 m/s²) than lower-level teams.

In addition, regarding the influence of the match result (win, loss, draw), all running distance variables were generally thought to be higher in won matches than in lost or drawn matches, but Nobari et al. (2021) showed different results. In particular, sprint distance in the first half was significantly higher in winning matches than in losing matches, and high-speed (18–23 km/h) distance in the second half of drawn matches was significantly lower than in losing matches. Thus, various studies have shown different results, and although the level of the opponent and the outcome of the match exert influences, no common consensus has been reached.

Internationally, numerous studies have been published on the physical demands of playing soccer for elite male (Bangsbo et al., 2006; Bradley et al., 2009; Dellal et al., 2011), elite female (Krustrup et al., 2005; Ramos et al., 2019), youth and college (Castagna et al., 2003; Curtis et al., 2018; Goto & Saward, 2020; Vigh-Larsen, Dalgas, & Andersen, 2018) soccer players. In recent years, the development of the Global Navigation Satellite System (GNSS) enabled the more precise assessment of activity during matches and practice. However, such systems are expensive and difficult for youth or college teams with limited budgets to access, so very few studies have reported on youth soccer teams in Japan (Mukaimoto, Ito, Kono, Nomura, & Saijo, 2014; Nakanishi et al., 2017; Ogai et al., 2021; Suenaga, Suzuki, & Akui, 2021).

Japanese college soccer teams engage in a variety of competitions throughout the season, including leagues, cups, and tournaments (Japan_University_Football_Association_Tokai, 2024). Consequently, it is imperative to meticulously monitor the external and internal loads of the team and individual players, taking into account player rotation and substitution strategies.

This study therefore aimed to quantify the physical demands placed on players during matches in a Japanese Division I collegiate men's soccer team. We also investigated the effects of position (forwards [FWs], midfielders [MFs], defenders [DFs]), role (starter, non-starter), and the competitive level of the opponents (higher-level team, lower-level team) on the physical demands during matches.

Material & methods

Participants

Twenty-nine collegiate male soccer players (age: 19.7 ± 1.0 years; height: 175.7 ± 6.3 cm; body mass: 70.6 ± 6.8 kg) belonging to the Tokai Division 1 league participated in this study. Data from players who completed full matches was retained for analysis. Players were categorized according to playing position as FWs, MFs and DFs. Prior to data collection, ethics approval was obtained from the Health Research Ethics Committee at Chukyo University (approval no. 2021-068). Research was conducted in accordance with the Declaration of Helsinki. Subjects were informed of the potential benefits and risks of the investigation prior to signing an institutionally approved informed consent document to participate in the study.

Measures

Match data from one Tokai Division I men’s collegiate soccer team were collected over the 2022 competitive season from April to July. In total, 15 matches were recorded. These comprised 9 matches in the Tokai League Division I, 2 matches in the Aichi Tournament, and 4 matches in the Tokai tournament. The first two matches of the season were not able to be recorded because GNSS unit were unavailable at that time. The 15 recorded matches included 12 wins, one draw and two defeats. All matches were performed outdoors on natural grass or artificial grass.

The 15 official matches observed throughout the data collection period consisted of 14 regular matches (first and second halves) and 1 overtime match (an overtime period in addition to first and second halves). In total, 236 total match files were recorded throughout the season, but the analysis included only full match observations, defined as a player competing for ≥90 min in total during a single match.

Players who competed for < 90 min in total during a single match were excluded by standardizing match times to increase uniformity in comparisons across positions, roles, and competitive levels. Because of the inclusion of overtime, total match times in the current investigation averaged 99.9 min per match. A total of 88 individual match files were analyzed. Goalkeepers were excluded from analysis.

To identify running distance and intensity profiles by playing position, athletes were classified as either FW (n = 3 players, n = 8 files), MF (n = 15 players, n = 28 files), or DF (n = 9 players, n = 52 files). Players were classified into two groups according to playing status.

The two groups consisted of starters and non-starters and were classified based on the percentage of entire games played during the season. Starters played ≥ 60% of games (n = 9 players) and non-starters played < 60% of games (n = 16 players), as adapted from Anderson et al. (2016).

Twenty-five of the 27 players played at least one of the 15 games (8.1 ± 4.4 games/player), two players did not play at all, and no player played every game. Twenty-five players played at least one game as a starter (5.6 ± 4.7 games/player). The present study analyzed higher-level teams including five teams in the Tokai League Division IA and two professional teams (n = 8 games) and lower-level teams including six teams in the Tokai League Division IB (n = 7 games) in the first season of 2022.

Design and Procedures

Matches were analyzed with GNSS units sampling at 10 Hz (Digitalyst Type S; Digitalyst Ltd., Tokyo, Japan). GNSS units were fitted to the upper back of each player using a custom-designed vest. Units were turned on 10–15 min before the pre-match warm-up. For a movement to be recorded as an effort, players had to remain within that specific velocity range for at least 1.0 sec.

Locomotor activities were defined as previously reported for male soccer players(Anderson et al., 2016; Bradley et al., 2009; Curtis et al., 2021) as: zone 1, standing (0.0–0.69 km/h); zone 2, walking (0.7–7.1 km/h); zone 3, jogging (7.2–14.3 km/h); zone 4, running (14.4–19.7 km/h); zone 5, high-speed running (19.8–25.1 km/h); and zone 6, sprinting (> 25.2 km/h).

The number of accelerations and decelerations was counted as the player showing acceleration > 3 m/s2 or deceleration > 3 m/s2 for a period > 0.5 s, respectively (Crang et al., 2021; Hoppe, Baumgart, Slomka, Polglaze, & Freiwald, 2017; Rago, Rebelo, Krustrup, & Mohr, 2021; Russell et al., 2016). Data were categorized into total distance (m), relative distance (m/min), high-intensity running (HIR: > 14.4 km/h, consisting of running, high-speed running and sprinting), and very high intensity running (VHIR: > 19.8 km/h, consisting of high-speed running and sprinting). Zone 1 (standing) was excluded from analysis because of the lack of movement during games.

Horizontal dilution of precision (HDOP) indicates the accuracy of GNSS in a horizontal plane with optimal satellite availability. During games, the number of satellites connected to devices was 16.0 ± 0.8 (range, 13.0–18.0), with an average HDOP of 0.64 ± 0.08 (0.55–0.92). Data recorded on GNSS units were downloaded onto a personal computer and analyzed using the manufacturer-supplied software for soccer (Digitalist, 2022). An intelligent motion filter incorporated within the GNSS unit and software was used to exclude non-game activity, by considering stoppages in play such as during half-time and at the end of play. Raw data were also further divided into first-half and second-half files. GNSS Doppler data were used during the analysis of GNSS-related variables.

The GNSS units have good validity and reliability (± 2.5% CV) for total distance, linear running, and change of direction (Digitalist, 2022).

Statistical analysis

One-way analysis of variance was used to compare the physical demands of different positions, and Holm's method was used for multiple comparison tests. In addition, non-paired t-tests were used to compare the physical demands of different roles and the competitive level of opponents. All statistical procedures used probability values less than 5% to indicate significance.

Effect size from analysis of variance was determined using η^2, with 0.01–0.059 considered a small effect size, 0.06–0.139 a medium effect size, and ≥ 0.14 a large effect size. In addition, effect size was determined using Cohen's d in the t-test, with 0.2–0.49 as a small effect size, 0.5–0.79 as a medium effect size, and ≥ 0.8 as a large effect size.

Results

Regarding physical demands during matches, overall total distance was 10,590.6 ± 1,211.1 m, relative distance was 106.0 ± 9.8 m/min, HIR (> 14.4 km/h) distance was 2,329.4 ± 666.5 m, VHIR (> 19.8 km/h) distance was 751.6 ± 313.7 m, and zone 6 (> 25.2 km/h) distance was 155.8 ± 98.9 m (Table 1).

Table 1 shows averages and standard deviations for the physical demands during matches by position. MFs showed significantly higher total distances and relative distances than DFs ($p < 0.05$). Comparing distances at each running speed, MFs ran significantly longer in zone 4 than DFs ($p < 0.05$).

In terms of the percentage distance at each running speed, DFs showed a significantly higher percentage in zone 2 than MFs, and MFs had a significantly higher percentage in zones 3 and 4 than DFs ($p < 0.05$). MFs ran longer distances in HIR and their percentages than DFs, and FWs showed higher maximum accelerations than other positions ($p < 0.05$).

Table 1. Comparison of match demands by playing position

Variables		All (n = 88)	Defenders (n = 52)	Midfielders (n = 28)	Forwards (n = 8)	$f, p\ \eta^2$, *difference*	
Playing time (min)	*mean*	99.91	99.75	100.43	99.13	$F = 0.173, p = 0.841, \eta^2 = 0.004$	
	sd	6.22	6.01	6.69	5.64		
Total distance (m)	*mean*	10590.64	10267.31	11219.93	10489.75	$F = 6.274, p = 0.003, \eta^2 = 0.129$	*
	sd	1211.15	1154.68	1232.79	701.92	DF < MF	
Relative distance (m/min)	*mean*	105.98	102.88	111.75	105.88	$F = 8.726, p = 0.000, \eta^2 = 0.170$	**
	sd	9.77	9.02	9.67	6.47	DF < MF	
Distance of zone 2 (m)	*mean*	3937.48	3995.77	3830.36	3933.50	$F = 2.065, p = 0.133, \eta^2 = 0.046$	
	sd	349.51	348.83	358.25	288.05		
Distance of zone 3 (m)	*mean*	4335.66	4150.10	4710.57	4229.63	$F = 8.973, p = 0.000, \eta^2 = 0.174$	**
	sd	615.75	539.49	616.90	589.13		
Distance of zone 4 (m)	*mean*	1578.09	1446.42	1844.46	1501.63	$F = 10.320, p = 0.000, \eta^2 = 0.195$	**
	sd	413.18	348.14	452.48	232.53	DF < MF	
Distance of zone 5 (m)	*mean*	595.89	548.29	670.32	644.75	$F = 2.868, p = 0.062, \eta^2 = 0.063$	
	sd	229.12	208.07	264.69	180.52		
Distance of zone 6 (m)	*mean*	155.83	141.08	176.21	180.38	$F = 1.416, p = 0.248, \eta^2 = 0.032$	
	sd	98.94	86.58	122.70	80.09		
Ratio of zone2 (%)	*mean*	37.54	39.22	34.41	37.64	$F = 13.295, p = 0.000, \eta^2 = 0.238$	**
	sd	4.48	4.03	3.92	3.76	DF > MF	
Ratio of zone3 (%)	*mean*	40.89	40.39	42.03	40.20	$F = 3.451, p = 0.036, \eta^2 = 0.075$	*
	sd	2.84	2.10	3.57	3.54	DF < MF	
Ratio of zone4 (%)	*mean*	14.71	13.95	16.25	14.28	$F = 9.689, p = 0.000, \eta^2 = 0.186$	**
	sd	2.44	2.13	2.58	1.57	DF < MF	
Ratio of zone5 (%)	*mean*	5.54	5.26	5.88	6.16	$F = 1.661, p = 0.196, \eta^2 = 0.038$	
	sd	1.77	1.64	2.01	1.69		
Ratio of zone6 (%)	*mean*	1.43	1.33	1.53	1.76	$F = 1.217, p = 0.301, \eta^2 = 0.029$	
	sd	0.84	0.74	1.01	0.80		
Running distance at high intensity (m)	*mean*	2329.42	2135.29	2690.54	2327.38	$F = 7.123, p = 0.001, \eta^2 = 0.144$	**
	sd	666.46	604.20	724.30	314.75	DF < MF	
Ratio of sprinting distance at high intensity (%)	*mean*	21.68	20.53	23.66	22.16	$F = 5.401, p = 0.006, \eta^2 = 0.113$	**
	sd	4.26	4.05	4.49	2.35	DF < MF	
Running distance at very high intensity (m)	*mean*	751.59	689.33	846.18	825.25	$F = 2.579, p = 0.082, \eta^2 = 0.057$	
	sd	313.74	280.10	372.97	241.88		
Ratio of sprinting distance at very high intensity (%)	*mean*	6.96	6.59	7.40	7.90	$F = 1.640, p = 0.200, \eta^2 = 0.037$	
	sd	2.46	2.20	2.90	2.33		
Maximum acceleration (m/s^2)	*mean*	3.84	3.82	3.80	4.04	$F = 3.488, p = 0.035, \eta^2 = 0.076$	*
	sd	0.23	0.24	0.21	0.23	DF, MF < FW	
Maximum speed (km/h)	*mean*	29.20	29.27	28.98	29.49	$F = 0.588, p = 0.558, \eta^2 = 0.014$	
	sd	1.36	1.39	1.27	1.61		
Number of acceleration	*mean*	37.85	37.77	36.75	42.25	$F = 0.981, p = 0.379, \eta^2 = 0.023$	
	sd	9.76	9.54	11.15	5.23		
Number of deceleration	*mean*	38.81	37.54	41.75	36.75	$F = 1.356, p = 0.263, \eta^2 = 0.031$	
	sd	11.50	9.95	14.94	5.39		
Number of sprint	*mean*	7.97	7.13	9.21	9.00	$F = 1.750, p = 0.180, \eta^2 = 0.040$	
	sd	5.03	4.43	6.12	4.31		

Zone 2: walking (0.7–7.1 km/h); zone 3: jogging (7.2–14.3 km/h); zone 4: running (14.4–19.7 km/h); zone 5: high-speed running (19.8–25.1 km/h); and zone 6: sprinting (>25.2 km/h). High intensity running (HIR: > 14.4 km/h, consisting of running, high-speed running and sprinting);very high intensity running (VHIR: > 19.8 km/h, consisting of high-speed running and sprinting). * p<0.05; ** p<0.01

Table 2 displays a comparison of the physical demands of starters and non-starters in terms of player roles. Starters had significantly shorter average game time and total distance ($p < 0.05$). Non-starters therefore ran a greater relative distance. Starters also ran significantly less distance in zones 3, 4, and 5 ($p < 0.05$). In terms of the percentage running distance, starters ran a higher percentage in zone 2 with a non-significant but moderate effect size ($d = 0.607$), while non-starters ran a significantly greater percentage in zone 4 ($p < 0.05$). Thus, non-starters ran a greater percentage of high-intensity running and very high intensity running than starters. No differences were seen in maximum speed or maximum acceleration, but non-starters accelerated and decelerated more frequently than starters ($p < 0.05$).

Table 2. Comparison of match demands between starter and non-starter players

Variables		Starters (n = 68)	Non-starters (n = 20)	*t* value, difference, *p* value,*d*	
Playing time (min)	*mean*	98.69	104.05	*t* = -2.241, *df* = 20.307,*p* = 0.0363, *d* =0.933	*
	sd	3.55	10.25		
Total distance (m)	*mean*	10294.90	11596.15	*t* = -3.636, *df* = 23.447, *p* = 0.00135, *d* =1.208	**
	sd	932.95	1478.70		
Relative distance (m/min)	*mean*	104.29	111.70	*t* = -2.570, *df* = 24.765, *p* = 0.0166, *d* = 0.802	*
	sd	8.40	11.74		
Distance of zone 2 (m)	*mean*	3891.03	4095.40	*t* = -1.605, *df* = 21.399, *p* = 0.123, *d* = 0.607	
	sd	251.53	538.63		
Distance of zone 3 (m)	*mean*	4213.12	4752.30	*t* = -2.821, *df* = 23.289, *p* = 0.010, *d* = 0.945	*
	sd	490.44	791.07		
Distance of zone 4 (m)	*mean*	1487.13	1887.35	*t* = -3.339, *df* = 24.308, *p* = 0.003, *d*= 1.063	**
	sd	337.23	490.62		
Distance of zone 5 (m)	*mean*	562.63	708.95	*t* = -2.417, *df* = 28.469, *p* = 0.022, *d* = 0.663	**
	sd	215.57	237.57		
Distance of zone 6 (m)	*mean*	151.41	170.85	*t* = -0.812, *df* = 34.025, *p* = 0.423, *d* = 0.197	
	sd	101.15	89.41		
Ratio of zone2 (%)	*mean*	38.09	35.70	*t* = 1.826, *df* = 25.730, *p* = 0.079, *d* = 0.548	
	sd	4.06	5.27		
Ratio of zone3 (%)	*mean*	40.91	40.83	*t* = 0.117, *df* = 30.451, *p* = 0.907, *d* = 0.031	
	sd	2.84	2.85		
Ratio of zone4 (%)	*mean*	14.30	16.10	*t* = -2.533, *df* = 25.328, *p* = 0.018, *d* = 0.772	*
	sd	2.14	2.86		
Ratio of zone5 (%)	*mean*	5.38	6.08	*t* = -1.490, *df* = 29.359, *p* = 0.147, *d* = 0.399	
	sd	1.73	1.82		
Ratio of zone6 (%)	*mean*	1.42	1.48	*t* = -0.286, *df* = 34.591, *p* = 0.777, *d* = 0.069	
	sd	0.86	0.75		
Running distance at high intensity (m)	*mean*	2200.63	2767.30	*t* = -3.267, *df* = 27.916, *p* = 0.003, *d* = 0.911	**
	sd	603.39	684.35		
Ratio of sprinting distance at high intensity (%)	*mean*	21.10	23.64	*t* = -2.354, *df* = 30.422, *p* = 0.025, *d* = 0.614	*
	sd	4.12	4.15		
Running distance at very high intensity (m)	*mean*	713.82	880.00	*t* = -2.057, *df* = 29.927, *p* = 0.048, *d* = 0.543	*
	sd	303.88	312.75		
Ratio of sprinting distance at very high intensity (%)	*mean*	6.80	7.54	*t* = -1.171, *df* = 30.472, *p* = 0.251, *d* = 0.305	
	sd	2.43	2.45		
Maximum acceleration (m/s/s)	*mean*	3.81	3.92	*t* = -1.529, *df* = 26.281, *p* = 0.138, *d* = 0.450	
	sd	0.22	0.27		
Maximum speed (km/h)	*mean*	29.17	29.29	*t* = -0.315, *df* = 28.878, *p* = 0.755, *d* = 0.085	
	sd	1.33	1.44		
Number of acceleration	*mean*	35.84	44.70	*t* = -3.831, *df* = 31.246, *p* = 0.001, *d* = 0.982	**
	sd	9.08	8.85		
Number of deceleration	*mean*	37.35	43.75	*t* = -2.004, *df* = 27.113, *p* = 0.055, *d* = 0.573	
	sd	10.70	12.70		
Number of sprint	*mean*	7.63	9.10	*t* = -1.203, *df* = 33.677, *p* = 0.238, *d* = 0.294	
	sd	5.11	4.57		

Zone 2: walking (0.7–7.1 km/h); zone 3: jogging (7.2–14.3 km/h); zone 4: running (14.4–19.7 km/h); zone 5: high-speed running (19.8–25.1 km/h); and zone 6: sprinting (>25.2 km/h).
High intensity running (HIR: > 14.4 km/h, consisting of running, high-speed running and sprinting);very high intensity running (VHIR: > 19.8 km/h, consisting of high-speed running and sprinting).* p<0.05; ** p<0.01

Table 3 shows a comparison of the physical demands of higher- and lower-level teams based on the competitive level of the opponents. Total and relative distances were significantly greater when playing against lower-level teams ($p < 0.05$).

In addition, running distances in zone 2 and zone 3 were significantly greater when playing against lower-level teams than when playing against higher-level teams ($p < 0.05$).

Table 3. Comparison of match demands between higher-level and lower-level teams

Variables		Higher-level teams (n = 49)	Lower-level teams (n = 39)	*t* value, difference, *p* value,*d*	
Playing time (min)	*mean*	98.96	101.33	*t = -1.802, df = 52.019, p = 0.077, d = 0.391*	
	sd	3.89	8.03		
Total distance (m)	*mean*	10253.83	1055.98	t = -3.338, df = 74.989, p = 0.001, d = 1.108	**
	sd	11057.72	1231.70		
Relative distance (m/min)	*mean*	103.63	109.13	t = -2.809, df = 83.855, p = 0.006, d = 0.588	**
	sd	9.66	8.96		
Distance of zone 2 (m)	*mean*	3825.30	4085.90	t = -3.693, df = 70.757, p = 0.000, d = 0.806	**
	sd	286.26	364.86		
Distance of zone 3 (m)	*mean*	4175.13	4570.08	t = -3.327, df = 79.425, p = 0.001, d = 0.682	**
	sd	564.95	596.50		
Distance of zone 4 (m)	*mean*	1544.07	1634.79	t = -1.147, df = 82.455, p = 0.255, d = 0.221	
	sd	414.91	403.90		
Distance of zone 5 (m)	*mean*	570.72	620.69	t = -0.894, df = 79.716, p = 0.373, d = 0.219	
	sd	223.20	234.00		
Distance of zone 6 (m)	*mean*	145.74	165.74	t = -0.846, df = 85.297, p = 0.400, d = 0.203	
	sd	104.47	90.56		
Ratio of zone2 (%)	*mean*	37.73	37.25	t = 0.563, df = 85.798, p = 0.575, d = 0.108	
	sd	4.81	4.00		
Ratio of zone3 (%)	*mean*	40.67	41.31	t = -1.262, df = 85.722, p = 0.211, d = 0.230	
	sd	3.02	2.53		
Ratio of zone4 (%)	*mean*	14.85	14.61	t = 0.356, df = 84.593, p = 0.723, d = 0.097	
	sd	2.55	2.30		
Ratio of zone5 (%)	*mean*	5.46	5.54	t = 0.0021, df = 80.168, p = 0.998, d = 0.042	
	sd	1.74	1.81		
Ratio of zone6 (%)	*mean*	1.37	1.47	t = -0.415, df = 85.448, p = 0.679, d = 0.117	
	sd	0.89	0.76		
Running distance at high intensity (m)	*mean*	2259.54	2421.36	t = -1.155, df = 82.830, p = 0.252, d = 0.245	
	sd	672.56	647.09		
Ratio of sprinting distance at high intensity (%)	*mean*	21.66	21.63	t = 0.094, df = 84.269, p = 0.925, d = 0.008	
	sd	4.43	4.04		
Running distance at very high intensity (m)	*mean*	716.15	786.46	t = -0.925, df = 81.913, p = 0.358, d = 0.225	
	sd	313.69	310.31		
Ratio of sprinting distance at very high intensity (%)	*mean*	6.82	7.01	t = -0.162, df = 82.408, p = 0.872, d = 0.077	
	sd	2.48	2.42		
Maximum acceleration (m/s^2)	*mean*	3.85	3.82	t = 0.503, df = 67.233, p = 0.617, d = 0.136	
	sd	0.20	0.27		
Maximum speed (km/h)	*mean*	29.13	29.26	t = -0.413, df = 76.106, p = 0.681, d = 0.100	
	sd	1.27	1.45		
Number of acceleration	*mean*	37.63	38.46	t = -0.512, df = 78.228, p = 0.610, d = 0.085	
	sd	9.38	10.19		
Number of deceleration	*mean*	39.13	38.44	t = 0.274, df = 86.000, p = 0.785, d = 0.060	
	sd	12.58	9.98		
Number of sprint	*mean*	7.26	8.69	t = -1.212, df = 83.433, p = 0.229, d = 0.287	
	sd	5.12	4.83		

Zone 2: walking (0.7–7.1 km/h); zone 3: jogging (7.2–14.3 km/h); zone 4: running (14.4–19.7 km/h); zone 5: high-speed running (19.8–25.1 km/h); and zone 6: sprinting (>25.2 km/h).
High intensity running (HIR: > 14.4 km/h, consisting of running, high-speed running and sprinting); very high intensity running (VHIR: > 19.8 km/h, consisting of high-speed running and sprinting).
* p<0.05; ** p<0.01

Discussion

This study quantified the physical demands of different positions during matches in a Japanese Division I collegiate men's soccer team and examined the effects of differences in player roles and the competitive level of opponents on physical demands.

Average total distance in 15 official matches for players who played ≥ 90 min was 10,590.6 ± 1,211.15 m in this study. Although this value was slightly lower than the average total distance covered by professional players (10,714–10,841 m) (Bradley, Di Mascio, Peart, Olsen, & Sheldon, 2010; Bradley et al., 2009), collegiate soccer players in this study ran about 97.7–98.8% of the distance of professionals in a 90-min match. On the other hand, previous studies in Japan (Ogai et al., 2021; Suenaga et al., 2021) on college players showed a range of 11,076–11,373 m, and a previous study from the United States (Curtis et al., 2018) showed a range of 8,948–9,941 m. Those results differ from those of the team in this study, but this may be due to the fact that speed thresholds were different in previous studies: high intensity ≥ 14.40 km/h, sprinting ≥ 21.6 km/h (Curtis et al., 2018); : high intensity ≥ 21.0 km/h, sprinting ≥ 24.0 km/h (Ogai et al., 2021), which may have influenced the differences in total distance. When comparing running distances, setting the same speed threshold is essential.

As the competitive level increases, the speed during games is known to increase rather than total distance. Comparing running distances at different speeds at the same speed thresholds (Bradley et al., 2010; Bradley et al., 2009), the team in this study ran 2329.4 ± 670.3 m for HIR (> 14.4 km/h) compared with 2492–2725 m for professional players, 751.6 ± 315.5 m for VHIR (> 19.8 km/h) compared with 905–980 m for professional players, and 155.8 ± 99.5 m for sprinting (> 25.2 km/h) compared with 255–264 m for professional players. The difference between college players and professional players was more pronounced for high-intensity running and above, and the increase in running distance above the high-speed threshold is one factor that appears to contribute to improvement in competitive level.

In comparisons by position, similar to previous studies (Bradley et al., 2010; Bradley et al., 2009), MFs ran the longest total distance (11,219.93 ± 1,232.79 m), and MFs ran a significantly greater distance and its percentage during HIR (> 14.4 km/h) (2,690.54 ± 724.30 m, 23.66%) than DFs (2,329.42 ± 666.46 m, 21.68%). A more detailed comparison by position (Bradley et al., 2009) reported that wide MFs ran the most high-intensity running distance (3138 m), followed by central MFs (2825 m), fullbacks (2605 m), attackers (2341 m), and central DFs (1834 m). Previous studies of college teams (Curtis et al., 2018; Ogai et al., 2021; Suenaga et al., 2021) used different speed definitions, but reported that MFs ran the most in both total distance and HIR distance. MF is the position with the highest total distance and HIR distance at professional and college levels. In particular, because elite athletes average more than 2,700 m in HIR (Bradley et al., 2009), further improvement of HIR is needed regardless of position to raise the competitive level of college teams.

Since maximum acceleration during matches (4.04 m/s2) was greater for FWs than for DFs and MFs, FWs were more likely to be able to accelerate more sharply. However, this study found no differences between positions in the number of accelerations and decelerations. Varley and Aughey (2013) reported that wide DFs had the highest maximum acceleration, with no significant differences between other positions. In addition, wide DFs are required to both defend and attack, and are constantly moving back and forth, increasing the number of accelerations and sprints. Although the results differed from those of the present study, the playing style and tactical formation of the team can be assumed to exert an influence (Paul, Bradley, & Nassis, 2015), which may have influenced acceleration and deceleration movements by positions in this study.

Comparing starters and non-starters by role, non-starters had higher total distance, relative distance, low speed (zone 3), HIR (> 14.4 km/h) distance, VHIR (> 19.8 km/h) distance, and number of accelerations. Castillo-Rodríguez et al. (2023) reported that starters showed higher physical demands (total distance, numbers of accelerations and decelerations, explosive distance, etc.) than non-starters. Barreira et al. (2022) reported differences between starters and non-starters in total distance, exposure time, accelerations, and decelerations during games, and noted that starters experienced a higher external load than non-starters. Players who play few or no games are therefore required to undergo training to compensate for the external load during games, and standardizing the conditioning of each player is important. Anderson et al. (2016) also reported that starters ran more distance (14.4–19.7 km/h), ran more high-speed distance (19.8–25.1 km/h), and sprinted further (> 25.2 km/h) than non-starters. Those previous studies showed that the physical demands are higher for starters than for non-starters, but the results differed significantly from those of the present study. This was likely due to differences in the definitions of starters and non-starters. Castillo-Rodríguez et al. (2023) defined non-starters as players who played in the game for ≥ 15 min before the end of the game. Barreira et al. (2022) defined players as starters (starting in > 55% of games), fringe players (starting in 30–54% of games), or non-starters (starting in < 30% of games). Anderson et al. (2016) classified starters (starting in > 60% of games), fringe players (starting in 30–59.9% of games), and non-starters (starting in < 30% of games). We defined starters as those starting in > 60% of all games in the season, while non-starters started in < 60%. The number of players who fell into fringe players was small in this study, so our analysis included both fringe players (30–59.9%) and non-starters (< 30%) together as non-starters, which may have influenced the results. In the future, an increased number of matches may be needed to better analyze the three roles, including the fringe player category.

Non-starters had higher HIR (> 14.4 km/h) distance, VHIR (> 19.8 km/h) distance, and acceleration frequency than starters in this study. This may be because non-starters, who usually do not play as starters, played harder than starters when they played in the games for > 90 min. Coaching staff should provide players with weekly external loads in preparation for matches (Barreira et al., 2022). In particular, training sessions to compensate for match load are necessary for players who have played few or no games (Stevens, de Ruiter, Twisk, Savelsbergh, & Beek, 2017). Rotation of players throughout the season is an important factor in dealing with the high physical demands of soccer matches (Kołodziejczyk et al., 2021; Palucci Vieira et al., 2018), and the role of non-starters is likely to have some impact on team performance and wins and losses.

When comparing opponents, total distance, relative distance, and distance in zone 2 (walking: 0.7–7.1 km/h) and zone 3 (jogging: 7.2–14.3 km/h) were significantly longer against lower-level teams than against higher-level teams in this study. Folgado et al. (2014) found no difference in total distance between first division, second division, and amateur teams. On the other hand, Lago et al. (2010) reported that total distance was longer when opponents were of higher level. The present results differed from those of previous studies, and no common findings could be found.

Folgado et al. (2014) reported moderate intensity running distances (3.6–14.3 km/h) were most common when playing against amateur teams. Moderate intensity running in that study corresponds to zone 2 and 3 intensities in this study, and results were similar to those of this study. However, Lago et al. (2010) reported that low-intensity running (< 14.1 km/h) distances were higher when opponents were at a higher level. The speed definition in that study corresponds to zone 2 and 3 intensities in this study, but the results differed from those of the present study. (Folgado et al., 2014) compared different levels of leagues and amateur teams, while Lago et al. (2010) compared teams ranked by wins and losses within the same league. In addition to comparing teams ranked by wins and losses within the same college league, the present study also included two games against professional teams. This may have been influenced by the fact that a mixed tournament including professional and amateur teams called the Emperor's Cup was held during the season, giving college teams an opportunity to play against professional teams.

This study quantified the physical demands by position during matches in a Japanese division I collegiate men's soccer team, and further examined the effects of player roles and the competitive level of opponents on physical demands. However, the first limitation of the study was the small sample size. Only 15 matches in the first half of the season were included in this study. In addition to the 15 matches in the first half of the season, 13 matches were played in the second half of the season, but we were unable to collect match data from the second half of the season this time. In the future, analysis of many matches in the first and second halves of the season should be included to examine physical demands during matches. In addition, analysis of players by the three roles of starter, fringe, and non-starter would have been desirable, as in previous studies (Anderson et al., 2016). However, this study was only able to analyze the two roles of starter and non-starter. More detailed analysis was not possible because too few players were categorizable as fringe players. An increase in the number of matches in the second half of the season in addition to the first half of the season would be needed to appropriately identify fringe players. The second limitation was that speed thresholds have varied widely among previous studies (Akenhead, Harley, & Tweddle, 2016; Curtis et al., 2018; Ogai et al., 2021; Rago et al., 2021; Russell et al., 2016). Differences in speed thresholds may affect measurements such as running distance, intensity, and number of sprints, which may in turn affect the interpretation of results. Appropriate speed thresholds need to be considered in the future. A third limitation was that we were unable to obtain GNSS data from opponents. Running performance during matches may be affected by the playing style and tactical formation of the team (Paul et al., 2015). However, we were only able to equip the team with GNSS devices in this study and did not consider the playing style and tactical formation of higher- and lower-level teams. In addition, this study compared playing levels within the same league, but comparisons with different leagues and college leagues in other regions may provide more generalizable insights into the physical demands of college soccer players.

Conclusions

This study examined the effects of positions, player roles, and the competitive level of opponents on physical demands during matches in a Japanese Division I collegiate men's soccer team. College soccer players in this study ran a total running distance similar to that of professionals during a 90-min match. Running distance during HIR or higher needs to be increased to improve the competitive level of college soccer players in this study. In comparisons by position, MFs achieved higher total and HIR distances than other positions. In comparisons by player role, non-starters ran greater HIR and VHIR distances and had a greater number of accelerations than starters.

The results showed that non-starters played harder than starters when they played as starting members for ≥ 90 min. In comparisons by the competitive level of opponents, total distance, relative distance, and low- to moderate-intensity running distance were higher when playing against a lower-level team than against a higher-level team, but no common findings were found compared to previous studies. High-intensity running distances will need to continue to improve, regardless of position, to raise the level of competition for collegiate teams. In addition, player rotation during matches will be an important tactic, making high physical demands on non-starters essential.

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Conflicts of interest - There is no conflict of interest.

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