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ORIGINAL ARTICLE

Impact of contextual variables on the representative external load profile of Spanish professional soccer match-play: A full season study

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Abstract
The aims of this study were to: (1) identify the representative external load profile of match-play in Spanish professional soccer players by principal components analysis (PCA), and (2) analyse the effect of match location (home vs away), match outcome (win vs draw vs loss) and length of the microcycle (5 vs 6 vs 7 vs 8 vs 9 days) on the external load profile. Data were collected during one season consisting of 42 matches in LaLiga 123 and 11 external load variables were selected after the PCA. TD, total distance covered; $DIS_{0–6}$: distance from 0 to 6 km/h; $DIS_{21–24}$: distance from 21 to 24 km/h; HSRD: high-speed running distance above 21 km/h; HSRA: total of high-speed running actions above 21 km/h; V_{MAX}: maximum speed in km/h; Sprints: total of actions above 24 km/h; ACC: total of accelerations; $ACC_{G\text{-}avg}$: average accelerometer G-force; ACC_{MAX}: maximum acceleration (m/s2); DEC_{MAX}: maximum deceleration (m/s^2). Match location had an impact on HSRD ($p < 0.01$; ES = 0.05), $DIS_{0–6}$ ($p < 0.01$; ES = 0.05), and ACC_{MAX} ($p < 0.01$; ES = 0.05). Match outcome had a relation to TD ($p < 0.01$; ES = 0.05), $DIS_{0–6}$ ($p < 0.01$; ES = 0.05) and HSRD ($p < 0.01$; ES = 0.05). Length of the microcycle had an impact on TD ($p < 0.01$; ES = 0.05), $DIS_{0–6}$ ($p < 0.01$; ES = 0.11), ACC ($p < 0.01$; ES = 0.04) and V_{MAX} ($p < 0.01$; ES = 0.04). This study provides coaches a selection of variables for match-play analysis, which could represent two-thirds of external load profile. Then, professionals should consider that these contextual variables could have an impact on the external load profile.

Keywords: *Load, monitoring, performance, situational variables*

Highlights

- Eleven external load variables were extracted by the PCA, which included: TD, $DIS_{0–6}$, $DIS_{21–24}$, HSRD, HSRA,V_{MAX}, Sprints, ACC, $ACC_{G\text{-}avg}$, ACC_{MAX} and DEC_{MAX}.
- Match location had an impact on HSRD, $DIS_{0–6}$, and ACC_{MAX}.
- Match outcome had a relation to TD, $DIS_{0–6}$ and HSRD.
- Length of the microcycle had an impact on TD, $DIS_{0–6}$, ACC and V_{MAX}.

Introduction

Soccer is a team sport with high complexity and technical–tactical basis help to achieve successful results in matches (Vescovi, Rupf, Brown, & Marques, 2011). However, physical fitness in such an explosive team sport is deemed important (Drust, Cable, & Reilly, 2000; Varley & Aughey, 2012). Recently, the evolution of Global Positioning Systems (GPS) has allowed the load monitoring of professional soccer players (Cummins, Orr, O'Connor, & West, 2013) during training and match (Gabbett, 2016). In addition, new Wireless Inertial Measurement Units (WIMUs) have been developed with GPS and inertial sensors (accelerometers, gyroscopes) embedded in

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the devices (Chambers, Gabbett, Cole, & Beard, 2015). GPS provides data on positioning-derived variables (distance, speed) while WIMUs provide data on impacts, jumps, changes of direction, etc. (Chambers et al., 2015).

Currently, one of the main challenges for researchers, sport scientists or strength and conditioning coaches is the identification and selection of the representative performance variables. Principal component analysis (PCA) is one of the statistical methods which may provide a solution to this area of sports science (Rojas-Valverde, Gómez-Carmona, Gutiérrez-Vargas, & Pino-Ortega, 2019). PCA has previously been used for talent detection of soccer players (Gløersen, Myklebust, Hallén, & Federolf, 2018). This method selects the significant variables and disregards the least important components of the analysis (Parmar, James, Hearne, & Jones, 2018) so the data analysis process is optimized and the representative performance variables may be obtained (Musa, Razali Abdullah, Bisyri Husin Musawi Maliki, Azura Kosni, & Haque, 2016).

The external load profile has been analysed taking into consideration different contextual variables which include player's age (Palucci-Vieira et al., 2018), type of turf (Vescovi et al., 2011), opponent standard (Rago, Rebelo, Krustrup, & Mohr, 2019), playing position (Martin-Garcia, Diaz, Bradley, Morera, & Casamichana, 2018; Pettersen & Brenn, 2019) match location (Aquino, Munhoz-Martins, Palucci-Vieira, & Menezes, 2017; Castellano, Blanco-Villaseñor, & Álvarez, 2011; Rago et al., 2019), match outcome (Aquino et al., 2017; Castellano et al., 2011; Rago et al., 2019) and length of the microcycle (i.e. weekly training periods of several days counting from the day after the match to the following match, which may vary according to players' schedule, physical recovery or conditioning requirements) (Clemente et al., 2019; Curtis et al., 2019). Specifically, match location, match outcome and length of the microcycle have a meaningful impact on players' performance during competitive matches in professional soccer (Aquino et al., 2017; Castellano et al., 2011; Clemente et al., 2019; Rago et al., 2019). However, research on soccer concerning contextual variables mentioned above, which can contribute to variations in physical and performance characteristics (Lockie et al., 2014; Martin-Garcia et al., 2018), is limited to date. In consequence, investigations on the effect of these match-related contextual variables need to be conducted over complete seasons (Rago et al., 2019).

Therefore, given the lack of research on the representative variables of professional match-play and the impact that different contextual variables may have on the competitive external load profile, the aims of this study were to: (1) identify representative external load profile of match-play in Spanish professional soccer players by PCA, (2) analyse the effect of match location (home vs away), match outcome (win vs draw vs loss) and length of the microcycle (5 vs 6 vs 7 vs 8 vs 9 days) on the external load profile.

Methods

Experimental approach to the problem

A cohort study was conducted from August 2018 to June 2019 including 42 official matches from LaLiga 123 in 2018–2019 season. Matches were played on Friday, Saturday or Sunday depending on the official calendar so the length of the microcycles continually varied. Half of the matches were played at home and the other half were played away. The team formation was 4–4–2 in every match. Data were collected by wearable devices for time-motion analysis of the external load profile.

Participants

Data were collected from 26 male professional soccer players (age: 26.28 ± 3.82 years old; height: 1.818 ± 0.06 m; weight: 75.46 ± 6.67 kg; soccer playing experience: 19.38 ± 3.81 years; professional playing experience: 8.39 ± 2.82 years) belonging to a team in LaLiga 123. Players from different positions were included in the analysis: forwards (FW, $n = 4$), midfielders (MF, $n = 6$), wide-midfielders (WMF, $n = 5$), full-backs (FB, $n = 6$) and central defenders (CD, $n = 5$). Players who did not play the whole match were not included in the analysis. In addition, goalkeepers were excluded from the analysis due to the different nature of their activity-demands profile.

Procedures

WIMU Pro (RealTrack Systems, Almeria, Spain) was used to collect data at 10 Hz sample frequency. Prior to the start of the session, every device was calibrated following the instructions from the manufacturing company. The instructions were to: first, place the device on a flat surface; then turn it on without surrounding magnetic devices; finally, wait for 30 s. At that moment, the devices were placed in a pocket at the back of a chest vest. The validity and reliability of this device for measuring positioning metrics have previously been tested (Muñoz-López, Granero-Gil, Pino-Ortega, & De Hoyo, 2017). In addition, it is a frequently used device in soccer research (Bastida Castillo, Gómez Carmona, De la Cruz Sánchez, & Pino Ortega, 2018; Rago et al., 2019).

Once the session finished, data were transferred to SPRO software for performance analysis (RealTrack Systems, Almeria, Spain) of different variables.

Variables

Time-motion analysis of the external load profile. The electronic performance tracking system provided 262 variables with total values, peak and time-related. To compare workload variables between players, independent of playing time, maximum and relative variables were selected ($n = 49$). Prior to the PCA, the 49 maximum and relative variables were examined to select uncorrelated representative variables (Tabachnick & Fidell, 2007). Then, uncorrelated variables ($r < 0.7$) were considered for analysis (Pino-Ortega, Gómez-Carmona, Nakamura, & Rojas-Valverde, 2020; Rojas-Valverde, Sánchez-Ureña, et al., 2019). Finally, PCA was performed following previously published guidelines (Federolf, Reid, Gilgien, Haugen, & Smith, 2014; Rojas-Valverde, Sánchez-Ureña, et al., 2019). Variables with variance = 0 were excluded, a total of 14 variables were scaled and centred (*Z*-score): TD, total distance covered in metres per minute; DIS_{0-6}: distance covered in metres per minute from 0 to 6 km/h; DIS_{21-24}: distance covered in metres per minute from 21 to 24 km/h; HSRD: high-speed running distance covered in metres per minute above 21 km/h; HSRA: total of high-speed running actions per minute above 21 km/h; V_{MAX}: maximum speed in km/h; Sprints: total of actions above 24 km/h per minute; ACC: total of accelerations per minute; $ACC_{G\text{-}avg}$: average accelerometer G-force; ACC_{MAX}: maximum acceleration in m/s^2; DEC_{MAX}: maximum deceleration in m/s^2. Some of these variables were expressed as relative (to time, i.e. per minute) variables since not all the matches had a similar duration (94.40 ± 2.89 min). This is a criterion which several previous investigations (Harper, Carling, & Kiely, 2019; Pons et al., 2019; Vescovi & Falenchuk, 2019) have also used to homogenize the average demands of each match.

Match location. Matches were played at home and away.

Match outcome. Final score of every match was categorized as win, draw or loss.

Length of the microcycle. The structure of the microcycles registered ranged from 5 to 9 days.

Statistical analysis

The principal component analysis was performed following the protocol described in Figure 1 based on previous published guidelines (Federolf et al., 2014; Gløersen et al., 2018; Rojas-Valverde et al., 2019). From a total of 262 variables assessed trough electronic performance tracking systems, only 49 peak and time-related variables were selected considering the particularities of the analysis. Prior to the Principal Component Analysis, variables were examined to select uncorrelated representative variables (Tabachnick & Fidell, 2007). Then, uncorrelated variables ($r < 0.7$) were considered for analysis (Pino-Ortega et al., 2020; Rojas-Valverde et al., 2019). Variables with variance = 0 were excluded, a total of 14 variables were scaled and centred (*Z*-score) (see selected measures in variables section). The Kaiser–Meyer–Olkin values (KMO = 0.778) and Barleth Sphericity test confirmed that PCA was suitable ($p < 0.01$) (Bartlett, 1954; Kaiser, 1960). Eigenvalues >1 were considered for the extraction of principal components (PC) (Kaiser, 1960). A VariMax-orthogonal rotation method was performed in order to identify the high correlation of components and guarantee that each principal component offered different information. A threshold of 0.6 in each PC loading was retained for interpretation, extracting the highest factor loading when a cross-loading was found between components. Authors did not limit the number of PCs of the model final outcome and PCs selection was based on the guidelines previously described.

A mixed analysis of variance was performed in order to compare match location and match outcome, while to compare workload demands between the length of the microcycles one-way ANOVA was performed. To explore the main effect of differences, the Bonferroni post-hoc was used. The magnitude of the differences was qualitatively interpreted using partial omega squared (ω_p^2) as follows: >0.01 *small*; >0.06 *moderate* and >0.14 *large* (Cohen, 1988). Statistical differences were considered if $p < 0.05$. Data analysis was performed using the Statistical Package for the Social Sciences (SPSS, IBM, SPSS Statistics, v.22.0 Chicago, IL, USA) and the graph was made using Prism software (GraphPad Software, San Diego, CA).

Results

Principal component analysis

Through PC analysis, eleven variables were extracted: TD, DIS_{0-6}, DIS_{21-24}, HSRD, HSRA, V_{MAX}, Sprints, ACC, $ACC_{G\text{-}avg}$, ACC_{MAX} and DEC_{MAX}. These variables explained a 66.8% of

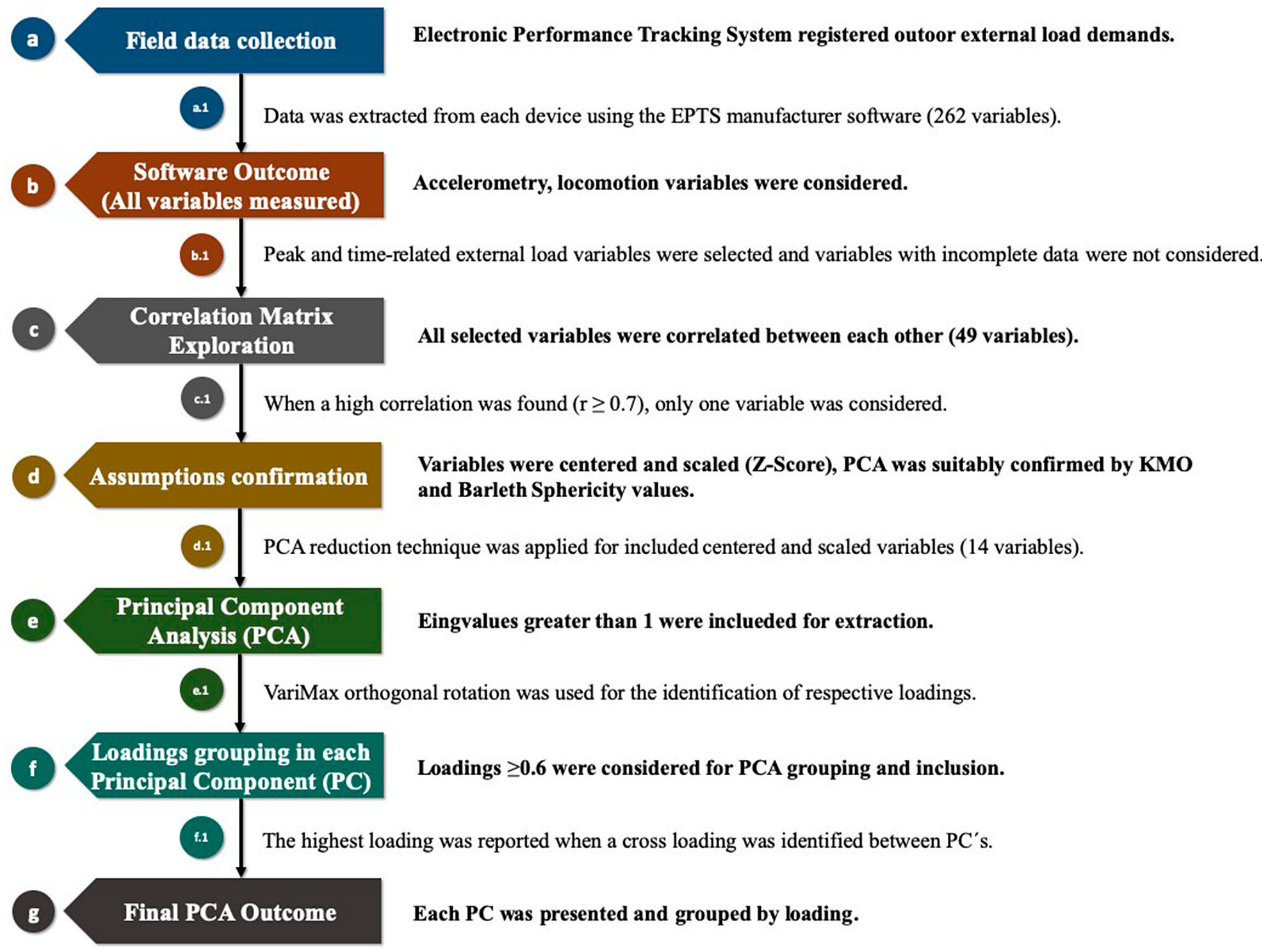

Figure 1. Flowchart of principal component analysis of variables assessed using Electronic Performance Tracking Systems.

total variance by four principal components. The PC1 (HSRD, HSRA, Sprints) explained a 36.2% of total variance (Figure 2).

Match location and match outcome

Table 1 shows the comparison of selected variables related to workload demands in relation to the interaction of match location and match outcome. Differences in DEC_{MAX} were found with the interaction of match outcome and match location. Regarding match location, statistical differences were found in HSRD (home > away in winning), TD (home > away in losing), $DIS_{0–6}$ (away > home in winning, losing and drawing matches), and DEC_{MAX} (home > away in winning). Finally, in match outcome analysis, differences were reported in HSRD (loss > draw in home; loss > draw = win in away), TD (loss = win > draw in home; win > draw = loss in away), $DIS_{0–6}$ (loss > draw in home; win > draw = loss in away) and DEC_{MAX} (win > loss in home).

Length of the microcycle

Finally, the differences between the length of the microcycle in external workload during the entire season are shown in Table 2. Differences in TD ($F = 4.42$; $p < 0.01$; $\omega_p^2 = 0.05$ *low*), $DIS_{0–6}$ ($F = 10.22$; $p < 0.01$; $\omega_p^2 = 0.11$ *moderate*) and ACC ($F = 4.27$; $p < 0.01$; $\omega_p^2 = 0.04$ *low*) were found with lower values in 9-days microcycle respect to 5-to-8-days microcycle. Besides, differences in V_{MAX} were found between 8-days microcycle respect to 5-days and 9-days microcycle ($F = 3.79$; $p < 0.01$; $\omega_p^2 = 0.04$ *low*), with the highest values (31.96 ± 2.05 km/h) in 8-days microcycle.

Discussion

The purpose of this study was to identify the representative external load profile of match-play in Spanish professional soccer players by using PCA and then, analyse the impact that different contextual variables (match location, match outcome and length of the

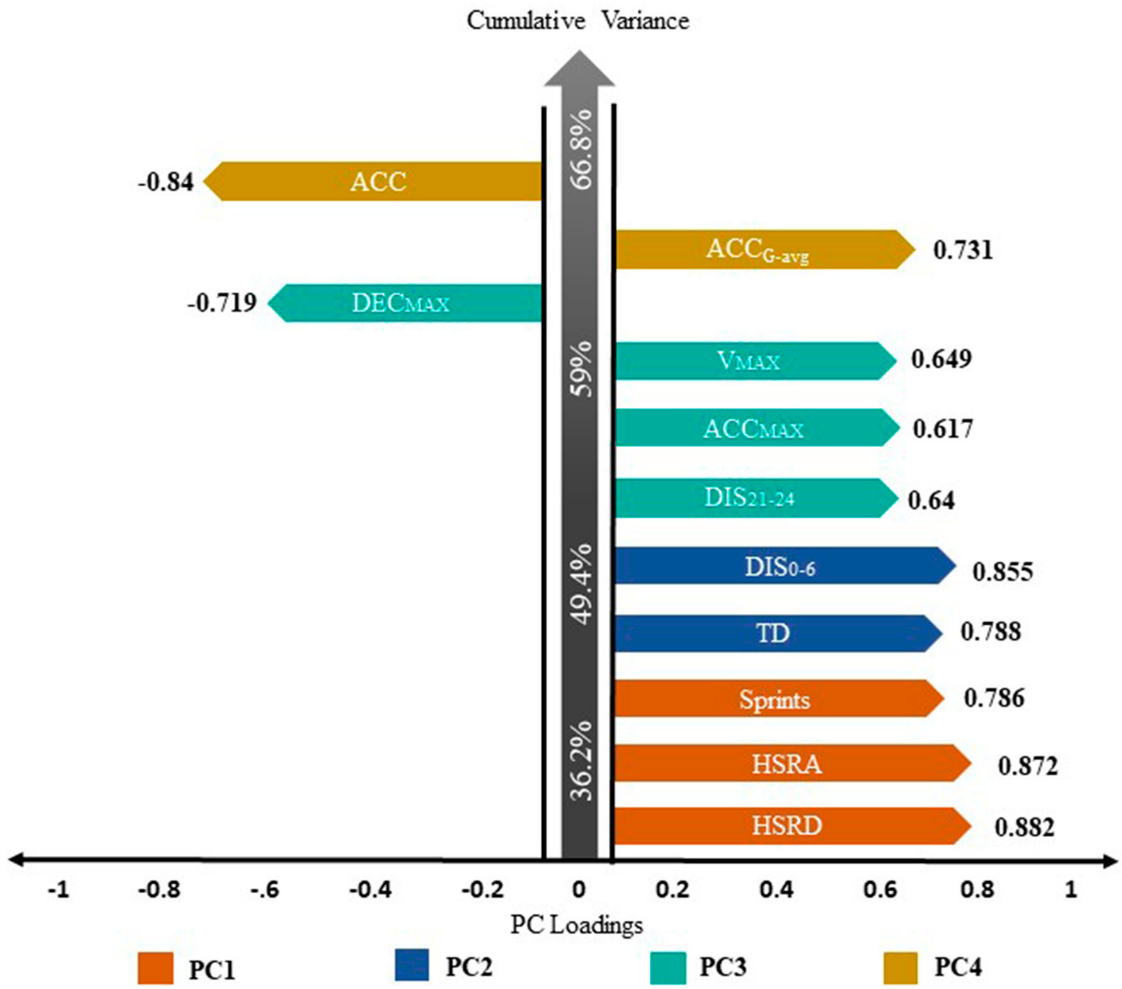

Figure 2. Representation of principal component analysis in workload profile of official matches played by an elite-level soccer team during an entire season.

microcycle) could have on the external load profile. This study identified that TD, $DIS_{0–6}$, $DIS_{21–24}$, HSRD, HSRA, V_{MAX}, Sprints, ACC, $ACC_{G\text{-}avg}$, ACC_{MAX} and DEC_{MAX} explained two-thirds of total variance of the external load profile in professional match-play over one full season. In addition, the results showed that contextual variables as match location (HSRD, $DIS_{0–6}$ and ACC_{MAX}), match outcome (TD, $DIS_{0–6}$ and HSRD) and length of microcycle (TD, $DIS_{0–6}$, ACC and V_{MAX}) may have an impact on locomotion profile during the whole season.

The PCA reported that 11 relative variables from a total of 262 should be selected, which explained 66.8% of total variance by four principal components. The main component was PC1 (HSRD, HSRA, Sprints) followed by PC2 (TD, $DIS_{0–6}$), PC3 (V_{MAX}, ACC_{MAX}, DEC_{MAX}, $DIS_{21–24}$) and PC 4 (ACC and $ACC_{G\text{-}avg}$). It is worth to highlight that most of the variables are distance-related and the main component (PC1) contains only high-intensity variables. This could support why previous research on soccer performance has mainly focused on measuring distance and speed-related variables (Aquino et al., 2017; Dalen, Jørgen, Gertjan, Geir Havard, & Ulrik, 2016; Palucci-Vieira et al., 2018; Rago et al., 2019). There are two components (PC3 and PC4) which explained that accelerations-related variables are also important, so it agrees with previous studies that considered necessary the understanding of the acceleration profile of professional soccer players (Buchheit et al., 2014; Dalen et al., 2016; Harper et al., 2019; Newans, Bellinger, Dodd, & Minahan, 2019; Rago et al., 2019; Russell et al., 2016; Vigh-Larsen, Dalgas, & Andersen, 2018). For example, it should be considered that accelerations cause a high metabolic cost (Hader et al., 2016) and decelerations increase the mechanical load (Dalen et al., 2016). However, no studies have included $ACC_{G\text{-}avg}$, which is an accelerometer-derived variable, despite several studies have analysed similar parameters such as total of low, mid and high G-force impacts (Arruda et al., 2015; Russell et al.,

Table 1. Differences between match location and match outcome in the workload profile of an elite-level soccer team during an entire season.

Variables		Home	Away	Match location	Differences
HSRD (m/min)	Loss	2.33 ± 1.50	2.08 ± 1.30	**4.45 (.03)**	
	Draw	1.83 ± 1.38	1.63 ± 1.11		
	Win	2.10 ± 1.25	1.50 ± 1.60		*
	Match outcome	**3.05 (.05)**		*Interaction*	
	Post-hoc	a	ab	0.63 (.54)	
HSRA (n/min)	Loss	0.47 ± 0.14	0.45 ± 0.14	2.65 (.10)	
	Draw	0.49 ± 0.18	0.49 ± 0.15		
	Win	0.50 ± 0.13	0.43 ± 0.17		
	Match outcome	2.65 (.06)		*Interaction*	
	Post-hoc			0.76 (.47)	
Sprints (n/min)	Loss	0.16 ± 0.07	0.16 ± 0.07	1.42 (.23)	
	Draw	0.18 ± 0.09	0.18 ± 0.09		
	Win	0.19 ± 0.08	0.16 ± 0.10		
	Match outcome	1.13 (.32)		*Interaction*	
	Post-hoc			0.76 (.47)	
TD (m/min)	Loss	111.85 ± 9.45	106.49 ± 8.98	0.01 (.91)	*
	Draw	103.49 ± 24.31	107.13 ± 7.80		
	Win	111.40 ± 8.60	112.55 ± 10.07		
	Match outcome	**5.93 (<.01)**		*Interaction*	
	Post-hoc	ac	bc	2.40 (.09)	
$DIS_{0–6}$ (m/min)	Loss	34.54 ± 1.87	36.22 ± 3.41	**28.83 (<.01)**	*
	Draw	32.82 ± 5.52	35.17 ± 2.80		*
	Win	34.65 ± 2.18	38.68 ± 6.40		*
	Match outcome	**10.74 (<.01)**		*Interaction*	
	Post-hoc	a	bc	1.82 (.16)	
$DIS_{21–24}$ (m/min)	Loss	3.00 ± 0.87	2.79 ± 0.97	2.40 (.12)	
	Draw	3.08 ± 1.34	3.02 ± 1.01		
	Win	3.24 ± 1.09	2.85 ± 1.31		
	Match outcome	0.45 (.33)		*Interaction*	
	Post-hoc			0.48 (.62)	
ACC_{MAX} (m/s^2)	Loss	5.15 ± 1.29	5.40 ± 1.06	**3.63 (.05)**	
	Draw	5.21 ± 0.80	5.50 ± 0.99		
	Win	5.22 ± 0.66	5.36 ± 0.86		
	Match outcome	0.54 (.59)		*Interaction*	
	Post-hoc			0.23 (.80)	
V_{MAX} (km/h)	Loss	31.15 ± 2.06	30.74 ± 4.15	1.59 (.21)	
	Draw	30.79 ± 4.55	31.95 ± 2.32		
	Win	31.45 ± 3.40	31.38 ± 2.60		
	Match outcome	0.35 (.70)		*Interaction*	
	Post-hoc			1.22 (.30)	
DEC_{MAX} (m/s^2)	Loss	−6.33 ± 1.63	−6.75 ± 0.90	0.02 (.88)	
	Draw	−6.57 ± 1.09	−6.81 ± 0.88		
	Win	−6.97 ± 0.99	−6.48 ± 0.82		*
	Match outcome	0.33 (.72)		*Interaction*	
	Post-hoc	b		**4.16 (.02)**	
$ACC_{G\text{-}AVG}$ (G)	Loss	0.56 ± 4.18	0.58 ± 1.71	0.92 (.34)	
	Draw	0.58 ± 3.72	0.61 ± 4.10		
	Win	0.61 ± 0.42	0.60 ± 3.23		
	Match outcome	1.05 (.35)		*Interaction*	
	Post-hoc			1.68 (.19)	
ACC (n/min)	Loss	31.63 ± 2.67	31.87 ± 1.57	0.06 (.80)	
	Draw	30.97 ± 3.11	31.43 ± 2.03		
	Win	31.69 ± 1.48	31.21 ± 3.11		
	Match outcome	1.20 (.30)		*Interaction*	
	Post-hoc			1.00 (.37)	

Notes: Two-way independent measures ANOVAs being match location and match outcome the between matches factors. ANOVA main effects (Match location; Match outcome) and interactions (Match location × Match outcome) are presented as *F* score (*p*). Descriptive data are presented as mean (SD). Post-hoc Bonferroni was used for pairwise comparisons. Match outcome pairwise comparisons: [a]Differences between Loss and Draw ($p < .05$); [b]Differences between Loss and Win ($p < .05$); [c]Differences between Draw and Win ($p < .05$).
*Match location differences ($p < .05$).
Bold text represents statistical differences ($p < .05$).

Table 2. Differences between length of the microcycle in the workload profile of a professional soccer team during a full season.

Variables	Length of microcycle						
	5-days (M ± SD)	6-days (M ± SD)	7-days (M ± SD)	8-days (M ± SD)	9-days (M ± SD)	F (p)	ω_p^2
HSRD (m/min)	2.02 ± 1.42	1.85 ± 1.01	1.83 ± 1.21	2.18 ± 1.36	2.34 ± 1.75	1.26 (.29)	0.00
HSRA (n/min)	0.48 ± 0.16	0.47 ± 0.15	0.47 ± 0.14	0.53 ± 0.13	0.44 ± 0.21	1.10 (.36)	0.00
Sprints (n/min)	0.17 ± 0.09	0.17 ± 0.08	0.17 ± 0.08	0.20 ± 0.08	0.17 ± 0.09	1.63 (.17)	0.01
TD (m/min)	109.27 ± 8.61	107.49 ± 9.13	108.29 ± 8.81	111.74 ± 8.89	98.08 ± 34.22[abcd]	4.42 (<.01)	0.05
$DIS_{0–6}$ (m/min)	36.02 ± 2.77	35.39 ± 2.52	35.41 ± 2.90	34.25 ± 2.32	30.86 ± 7.62[abcd]	10.22 (<.01)	0.11
$DIS_{21–24}$ (m/min)	3.01 ± 1.12	2.92 ± 1.09	2.98 ± 1.10	3.41 ± 1.04	2.91 ± 1.41	1.66 (.16)	0.01
ACC_{MAX} (m/s^2)	5.21 ± 0.81	5.44 ± 0.81	5.26 ± 1.00	5.38 ± 0.56	4.91 ± 0.93	1.70 (.15)	0.01
V_{MAX} (km/h)	29.96 ± 4.01	31.67 ± 2.82	31.30 ± 3.29	31.96 ± 2.05[ae]	29.42 ± 6.32	3.79 (<.01)	0.04
DEC_{MAX} (m/s^2)	−6.50 ± 1.01	−6.81 ± 0.76	−6.79 ± 1.13	−6.68 ± 0.67	−6.37 ± 1.52	1.45 (.22)	0.00
$ACC_{G\text{-avg}}$ (G)	0.56 ± 0.10	0.59 ± 0.05	0.59 ± 0.10	0.60 ± 0.05	0.57 ± 0.15	1.46 (.21)	0.00
ACC (n/min)	31.90 ± 1.78	31.54 ± 1.77	31.84 ± 1.62	31.64 ± 2.18	29.89 ± 4.25[abcd]	4.27 (<.01)	0.04

Note: M: Mean; SD: Standard deviation; F: F-value ANOVA; p: significance; ω_p^2: omega partial squared.
[a]Statistical differences with 5-days ($p < 0.05$).
[b]Statistical differences with 6-days ($p < 0.05$).
[c]Statistical differences with 7-days ($p < 0.05$).
[d]Statistical differences with 8-days ($p < 0.05$).
[e]Statistical differences with 9-days ($p < 0.05$).

2016). The results from the PCA showed that $ACC_{G\text{-avg}}$ could be a very useful variable of analysis in soccer, which is a team sport with frequent physical contact (Arruda et al., 2015). This variable represents the average intensity of player's movements registered by the accelerometers (e.g. impacts, jumps, changes of direction) and thus, it is a useful indicator of external load (Chambers et al., 2015).

In addition, home matches had a high impact on HSRD (when winning) and $DIS_{0–6}$ (when losing) whereas away matches had a high impact on ACC_{MAX} (when winning, losing and drawing). HSRD was significantly greater at home when winning. These results are controversial since a recent study with professional soccer players observed higher values at home matches in high-intensity running parameters (HSRA and V_{MAX}) than away matches (Aquino et al., 2017) whereas another investigation showed no significant impact of match location on HSRD (Castellano et al., 2011). Concerning $DIS_{0–6}$, only one study examined the impact of match location on this variable (Castellano et al., 2011). It had been found that distances covered at low speed ($DIS_{0–6}$) were higher at home matches but without significant differences (Castellano et al., 2011). Furthermore, ACC_{MAX} was always higher playing away (winning, losing or drawing). A previous research, which analysed not only match demands but also training load, found that the volume of acceleration activities tended to be higher when preparing for away matches compared to home matches (Rago et al., 2019). This could be a seasonal training load strategy that strength and conditioning may use in order to adapt players to the effect that contextual variables such as match location may have on match performance (Rago et al., 2019). Therefore, future studies could focus on the relationship between training load during each match week on professional soccer and the influence of contextual variables. However, it is significant to mention that only three variables from the external load profile were significantly influenced by match location. This could be explained by previous studies which found that match location had only trivial effects on physical performance (Castellano et al., 2011; Zhou, Hopkins, Mao, Calvo, & Liu, 2019).

It was also found that match outcome had significant relation to performance in some variables of the external load profile. For example, losses significantly increased TD and $DIS_{0–6}$ (at home) as well as HSRD (at home and away). A previous study with professional soccer players observed that HSRD and TD also increased when losing even though variables such as $DIS_{0–6}$ decreased (Castellano et al., 2011). This may suggest that soccer players increased their maximal physical output in order to improve the final score (Castellano et al., 2011). Moreover, a significant increase in $DIS_{0–6}$ for wins (away) was observed, which could be explained by side effects of congested match schedule (Palucci-Vieira et al., 2017) or an increased physical output in other high-intensity variables. Finally, another study reported that TD, V_{MAX} and HSRA were greater when winning than losing (Aquino et al., 2017). However, these variables were not significantly related to match outcome in our study. Overall, wins and losses tend to have a relation to only distance-related variables (TD, HSRD, $DIS_{0–6}$) whereas draw matches tend to require less physical output. Nonetheless, there is a lack of agreement between studies since the relation between match outcome and the external load profile is highly dependent on additional contextual variables such as opponent level (Aquino et al., 2017; Castellano et al., 2011; Rago et al., 2019), effective playing time (Castellano et al., 2011), team style of play (Aquino et al., 2017) or match status (Castellano et al., 2011). For example, the match outcome is categorized in this study as a win, draw or loss, but within each category, the players' workload profile could be critically different depending on the course of the match (e.g. match status: whether the team was winning, drawing or losing) (Castellano et al., 2011).

Regarding the length of the microcycle, the main findings were that TD, $DIS_{0–6}$ and ACC were significantly lower in 9-days microcycles whereas the greatest V_{MAX} was observed in 8-days microcycles. No significant differences were found in the rest of parameters of the representative external load profile of match-play and this suggests that the external load profile is not highly influenced by the length of the microcycles (Lago-Peñas, Rey, Lago-Ballesteros, Casáis, & Domínguez, 2011), apart from 9-days microcycle. However, previous investigations showed that the longer the length of the microcycle, the higher the training loads (Clemente et al., 2019; Curtis et al., 2019) and small but positive correlation coefficients between weekly load and match demands were observed in HSRD ($r = 0.2$; $p = 0.04$), ACC ($r = 0.3$; $p = 0.01$) and DEC ($r = 0.2$; $p = 0.35$) (Clemente et al., 2019). Although our study did not analyse training load, the relationship between training load, match load and length of the microcycle might provide a better understanding of this result and thus, more research is needed in this regard. Our results showed a decrease in TD, $DIS_{0–6}$ and ACC in the longest microcycle, which could be explained by the effect of having more availability for tactical preparation of matches (Castellano et al., 2011). This last conclusion is significant since the volume of TD and ACC are potential load indicators (Gabbett, 2016). The fact that players may avoid residual fatigue by having enough time to recover between matches could explain why the greatest V_{MAX} was observed in 8-days microcycles (Lago-Peñas et al., 2011).

To the best of our knowledge, this is the first study to identify a representative external load profile of professional soccer match-play and then, to analyse the impact of different contextual variables on it. However, there are some limitations such as the use of GPS technology to quantify distance-related parameters, whose accuracy may decrease when running at higher speeds involving rapid changes of direction (Cummins et al., 2013), and the sample size, which was limited to professional soccer players from only one team. In consequence, playing position was not considered for the analysis. Future studies could consider these limitations, include other contextual variables (e.g. opponent level, effective playing time, playing position, match status) or analyse the relationship between training and match's representative external load profile. In addition, PCA methods, which may consider playing position, are needed in order to determine if the selection of the representative variables of the external load profile in professional soccer requires a more individualized approach.

Practical application

This study provides strength and conditioning coaches, sport scientists and performance analysts a novel selection of variables for match-play analysis in professional soccer, which represented two-thirds of the external load profile of match-play analysed using a PCA method over one complete season. The PCA is a statistical method that disregards the least important components of the analysis and therefore these variables could be used as the main external load indicators of match-play in professional soccer players. This becomes an important practical application since the data analysis and interpretation process is optimized. Given the results of the PCA, another practical application is that the analysis process may be performed for the entire team regardless of the playing position (excluding goalkeepers). This does not mean that the same load should be prescribed for all players, but that their performance data can be analysed regardless of their playing position.

Also, regarding coaching implications, a significant finding was that most of these variables are parameters related to distance covered, high-speed and high-intensity actions, which need to be trained in professional soccer given the importance in the external load profile of match-play. Finally, a further novel finding was that these fitness professionals should consider that different contextual variables such as match location, match outcome and length of the microcycle, could have an impact on some variables of the representative external load profile. In consequence, such contextual variables, which result in changes in workload and player's performance status, may be considered for smarter load prescriptions.

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Disclosure statement

None of the authors has a conflict of interest to declare, and all authors were involved in the study design, data collection and interpretation, and contributed to the writing of the manuscript. This manuscript is original and not previously published, nor is it being considered elsewhere until a decision is made as to its acceptability by the European Journal of Sport Science Review Board.

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