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Analysis of the submaximal intensity periods during the competitive microcycle in professional football players

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Rafa Nadal and Carlos Alcaraz of Spain in action against Tallon Griekspoor and Wesley Koolhof of Netherlands during their men's doubles second round tennis match at the Paris Olympic Games on July 30, 2024. (Photo by EFE/EPA/ Ritchie B. Tongo)

Abstract
The study aimed (a) to determine the conditional demands of external load based on the submaximal intensity periods (SubMIP) during the competitive micro-cycle, (b) to compare the number and duration of SubMIP events demanded in the different sessions carried out in the competitive micro-cycle and, additionally, (c) to compare these demands based on the SubMIP depending on the specific position occupied by the football players during the competitive micro-cycle. A total of 77 training sessions were analyzed during 15 competitive micro-cycles and 15 official league matches during the 2019-20 season (Azerbaijan Premier League) obtaining a total of 1,037 individual records from 22 players. Data were collected using GPS devices. To determine the percentage of the number of daily SubMIP events with respect to those found in the competition, these events were also relativized based on the individual profile showed by player in competition. The main findings of the study were the existence of significant differences ($p \leq .05$) in each of the variables between training days/competition and positions based on the SubMIP. Metrics such as distance at speed > 19.8 km/h (HSR), distance at speed > 25.2 km/h (Sprint), acceleration density (AccDens) and distance at high metabolic intensity > 25.5 W/kg (HMLD) accumulated values > 50 % of the number of SubMIP events on some days of the microcycle. However, other metrics displayed much lower ranges (less than 15 %) compared to the competition in terms of the number of events and time above the threshold established in meters per minute (Mmin) and mean metabolic power (MetPow) variables. These new findings suggest that it is appropriate to explore new alternatives for load control in team sports.

Keywords: GPS, physical demands, soccer, team sports, training load.

Introduction

The tools for monitoring athletes' internal and external load are part of the assessment in contemporary training methodology (Jaspers et al., 2017). In outdoor team sports the global positioning system (GPS) provides valuable data to coaches and researchers, enriching the understanding of training and competition sessions (Oliva-Lozano et al., 2022).

During the last seasons there has been an increase in physical demands in football matches (Barnes et al., 2014), being an aspect to be considered in the daily and weekly training schedules to achieve high levels of individual and collective performance (García et al., 2022; Jaspers et al., 2017; Reilly, 2005). On that context it is critical to manage optimal training load in terms of frequency, intensity, and volume (Akenhead et al., 2016; Gabbett et al., 2016) attending to individual competition demands (Illa et al., 2020b).

This study provides relevant information on the conditional demands across different variables in team sports during the competitive micro-cycle, in a similar manner to previous research (Diaz-Seradilla et al., 2022; García et al., 2022; Martin-Garcia et al., 2018). Recent studies have described microcycles based on different variables (with absolute values or relative to competing demands) (Akenhead et al., 2016; Diaz-Seradilla et al., 2022; Martin-Garcia et al., 2018), also studying the effect of the duration of the microcycle on the accumulated training load (Clemente et al., 2019; Oliva-Lozano et al., 2022) or comparing different training and matches micro-cycles structures (e.g., four training sessions and one official competition match) (Diaz-Seradilla et al., 2022), and how the distribution of the load can affect the result of the match (Chena et al., 2021).

Research into maximum intensity periods (MIPs) in football has grown, with studies in competition (Oliva-Lozano et al., 2020) and training (Dios-Álvarez et al., 2024) finding a link between the duration of the analyzed time window and the intensity displayed by players (Rico-González et al., 2022). However, considering the intermittence profile manifested in team sports (Johnston et al., 2014), the analysis based on absolute values or MIPs may not capture the full extent of a players activity (Carling et al., 2019; Gabbett et al., 2016), particularly during sub-maximal intensity periods. The exclusive use of information provided by MIPs for the purpose of prescribing training (Novak et al., 2021) limitation has raised the need for new ways to measure athletes' load during training and competition. Specifically, the MIP reports a single event that does not assess the demand to which players are subjected in sub-maximal intensity periods. In this sense, the high demands (sub-maximal) that are presented repeatedly (Carling et al., 2019), question the exclusive use of the information provided by the MIPs for the purpose of prescribing training (Novak et al., 2021).

For all these reasons, it seems opportune to research for new alternatives to quantify athletes' load during training and competition (Caro et al., 2022). Similar studies have been conducted in other sports such as futsal (Illa et al., 2020a; Johnston et al., 2020) and in training sessions (Illa et al., 2020b). Showing considerable variations for each metric during matches, with total distance and acceleration actions being the most demanding at sub-maximal intensities (80-90 % and > 90 % of MIP) compared to the rest of the variables analyzed (Illa et al., 2020). Regarding intensity distribution with respect to the MIP during competitive matches in Australian rugby and football, Johnston et al. (2020) concluded that the activity distribution decreased as it approached maximum values.

In relation to the analysis of the competitive micro-cycle, Illa et al. (2020a) found differences between training and competition days, specifically in Player Load metric, distance, high-intensity decelerations, and accelerations (Illa et al., 2020b).

In football, the competition has been studied from this approach (Caro et al., 2022), showing differences primarily in individual performance, especially in the variables of distance covered at speed > 19.8 km/h (HSR), acceleration density (AccDens), mean metabolic power (MetPow), meters per minute (Mmin) and in distance covered at high metabolic intensity > 25.5 W/kg (HMLD). There are also differences between halves in AccDens, MetPow and Mmin variables and between positions in MetPow and Mmin, in number of sub-maximal intensity (SubMIP) events and in time above the sub-maximal threshold (Caro et al., 2022).

The study aimed (a) to determine the conditional demands of external load based on the SubMIP periods during the competitive micro-cycle, (b) to compare the number and duration of SubMIP events demanded in the different sessions carried out in the competitive micro-cycle and, additionally, (c) to compare these demands based on the SubMIP depending on the specific position occupied by the football players during the competitive micro-cycle.

Method

Participants

Fourteen male professional footballers from the same Azerbaijan Premier League team participated in this study (73.74 ± 5.92 kg, 1.79 ± 0.05 meters, 23.86 ± 3.58 years). To qualify for the analyses, players needed to have completed at least three matches and all sessions of the analyzed micro-cycle. Thus, players in Return-To-Play processes, those doing specific post-training work (top-up), or those facing unusual circumstances (e.g., suspension from the next competitive match) were excluded. Daily data was recorded post each session or match. All participants were part of another published retrospective study (Caro et al., 2022).

All participants were informed of the study's risks and benefits and provided consent as per the Declaration of Helsinki (Fortaleza, 2013), approved by the Catalan Sports Council's Ethics Committee for Clinical Research, number 035/CEICGC/2021.

Experimental Approach

We analyzed 77 training sessions across 15 competitive micro-cycles and 15 official league matches during the 2019-20 season, totaling 1,037 individual records. Data were collected via GPS devices.

During matches, the team consistently employed a 1-5-3-2 formation, with positions being three central defenders (CD), two wing defenders (WD), two midfielders (MID), one attacking midfielder (OMID), and two forwards (FW).

Micro-cycle structure

The micro-cycle was adjusted according to the competitive calendar. The day after a match was a recovery (MD+1R) or compensation (MD+1C) day, followed by a rest day. Workload days (MD-4 and MD-3) were four and three days pre-match, with "tapering" days (MD-2 and MD-1) two days pre-match. Only micro-cycles following this structure, as validated in previous studies (Martin-Garcia et al., 2018; Oliva-Lozano et al., 2022), were considered to maintain consistency. Training sessions primarily utilized game-based drills in which the dimensions of the game space, the number of participating players, the series duration and other rules were modified to achieve the desired objectives.

During MD+1R, the focus was on recovery for players who participated > 60' in the match, involving low-intensity aerobic work, progressive runs up to 70% of subjective individual speed, mobility exercises, and myofascial massage with foam rollers. Those who played < 60' performed compensatory work to meet the competition's conditional load, incorporating gym strength work, small position games (< 50 m² per player) (Martin-Garcia et al., 2020), and sprints at maximum intensity were therefore carried out, as suggested in previous studies (Martin-Garcia et al., 2018).

MD-4 involved specific on-field strength work (exercises with dynamic correspondence with football, CoD, accelerations and decelerations, etc.), small-position games (< 50 m² per player) and small-sided games (SSGs) played in reduced space (< 50 m² per player), with the aim of stimulating the players neuromuscularly through acceleration, braking and direction changes (Martin-Garcia et al., 2018, 2020). MD-3 focused on tactical work using tasks involving a large number of players in a large space (> 150 m² per player), aiming to recreate competition context and facilitate high and very-high speed actions (Martin-Garcia et al., 2018).

MD-2 focused on collective tactical aspects using tasks in small spaces and analytical tactical situations (11 x 0). On MD-1, the focus was on individual tactical performance using rounds, analytical tactics, positional tactical work, and set pieces. Volume and intensity varied throughout the competitive micro-cycle, as shown in Table 1.

Table 1
Average data of training sessions and match.

Day type	*n*	Distance	HSR	VHSR	Acc	Dcc	m/min
MD+1R	48	1,910.43 ± 248.46	48.89 ± 60.31	4.56 ± 11.73	1.67 ± 2.054	1.25 ± 1.97	73.04 ± 14.03
MD+1C	37	5,695.19 ±1,527.96	276.64 ± 235.26	69.98 ± 96.44	49.47 ± 14.84	43.61 ± 17.10	78.19 ± 15.03
MD-4	188	5,089.92 ± 830.17	224.69 ± 221.26	22.64 ± 36.42	45.53 ± 15.15	31.67 ± 14.22	68.92 ± 14.62
MD-3	223	5,832.92 ± 922.15	231.46 ± 108.59	48.96 ± 41.89	55.4 ± 16.69	45.60 ± 15.89	70.95 ± 9.92
MD-2	211	4,202.95 ± 853.25	134.37 ± 123.49	20.13 ± 34.09	42.03 ± 13.19	31.47 ± 12.46	62.96 ± 11.15
MD-1	222	2,802.71 ± 594.03	65.00 ± 67.62	7.26 ± 15.18	32.53 ± 11.77	23.62 ± 10.60	55.11 ± 8.59
MD	108	10,482.95 ± 958.25	671.30 ± 270.42	124.55 ± 89.91	65.33 ± 15.58	78.32 ± 19.01	110.12 ± 9.19

n: individual records, Distance: Distance in meters, HSR: Distance traveled > 19.8 km/h, VHSR: Distance traveled > 25.3 km/h, Acc: number of accelerations above 3 m/s², Dcc: number of decelerations below -3 m/s², m/min: meters per minute

Instruments

External load was monitored using GPS devices (STATSPORTS® APEX ProSeries, Northern Ireland), recording load during training and matches. The devices had a configurable sampling frequency of 10 Hz to 18 Hz, included a 600 Hz accelerometer, a 400 Hz gyroscope, and a 10 Hz magnetometer, with a weight of 45 g and dimensions of 33 x 80 x 15 mm. The validity and reliability of the device reported an error of between 1-2 % in the distance for different validation tests (400 m and 128.5 m circuit) and maximum speed in the 20 m test (Beato et al., 2018). The players wore a special vest designed to place the device at the top of the back, between the shoulder blades (Beato et al., 2018; Gimenez et al., 2020).To ensure inter-device reliability, players used the same GPS throughout all recordings (Jennings et al., 2010) and data was managed by the same experienced individual.

Procedures

During each training session and match, the following variables were analyzed: distance traveled at speeds > 19.8 km/h (HSR [High Speed Running]), > 25.2 km/h (Sprint), acceleration density (AccDens), mean metabolic power (MetPow), meters per minute (Mmin) and distance traveled at high metabolic intensity > 25.5 W/kg (HMLD [High Metabolic Load Distance]), in line with previous research (Caro et al., 2022).

Data Acquisition and Processing

Devices were turned on 15’ before sessions and matches. Correct device operation was verified using live application offered by the devices (STATSPORTS® Apex Live). Raw data was exported using the brand’s software (STATSPORTS® 3.0.03112) and processed in Excel (MICROSOFT®, Redmond, WA, USA), filtering records at 10 Hz using a fourth-order, double-pass Butterworth filter to minimize anomalies. For each variable, the mean of the three highest MIPs in competition was calculated to get a value relative to 100% individual (Caro et al., 2022; Illa et al., 2020a).

Data was processed using R language script through R Studio software (RSTUDIO®, Boston, Massachusetts, USA), applying a threshold of 85 % of the maximum individual average for each variable (Caro et al., 2022). Number and duration of SubMIP events were extracted for each training day individually. The information was stored in a database for statistical analysis. To determine the percentage of daily SubMIP events relative to competition, these events were also relativized based on the individual profile shown by the player in competition.

Statistical analysis

Data were presented as mean ± standard deviation. Prior to statistical analysis, the Shapiro-Wilk test confirmed that the data did not follow a normal distribution. Given this result, a mixed linear model (GLM) was employed for each variable, considering the types of day and player positions. When significant differences were found ($p < .05$), post hoc tests using estimated marginal means (EMMs) were conducted to determine where these differences resided. Intra-session reliability was determined using Guttman’s Lambda 6 test with 95 % confidence intervals (Oosterwijk et al., 2016). To interpret the magnitude of differences found in the mixed linear model analysis, a standardized effect size (ES) was calculated as the ratio of the estimated effect divided by its standard error. This provides an indication of the practical significance of the observed effects. The effect sizes were evaluated in the context of the study, highlighting those contrasts that showed the most substantial differences. All statistical tests were performed using R software version 4.0.2 R Studio software (RSTUDIO®, Boston, Massachusetts, USA) with the “lme4”, “lmerTest”, and “emmeans” packages for fitting mixed models and conducting post hoc comparisons.

Results

There were 1,037 individual records analyzed (Table 2), distributed in MD+1R (48), MD+1C (37), MD-4 (188), MD-3 (223), MD-2 (211), MD-1 (222) and MD (108). Determining their reliability by calculating Guttman’s Lambda (G6) and coefficient of variation (CV) interval values for the different days: MD+1C (G6 95 % [CI] = 0.94-0.99; CV 95 % CI = 0.89-3.33), MD-4 (G6 95 % [CI] = 0.96-0.98; CV 95 % CI = 0.86-5.01), MD-3 (G6 95 % [CI] = 0.91-0.95; CV 95 % CI = 0.74-4.65), MD-2 (G6 95 % [CI] = 0.87-0.98; CV 95 % CI = 0.97-10.01), MD-1 (G6 95 % [CI] = 0.83-0.96; CV 95 % CI = 1.14-9.13), MD (G6 95 % [CI] = 0.99-0.99; CV 95 % CI = 0.59-2.02). The lower means are found in MD+1R in all the variables except in HSR, the lower HSR mean is found on day MD-1 (Table 2).

Table 2
Mean and Standard Deviation for each of the Day Types by Position.

Position	*n*		AccDens	Duration Acc Dens	MetPow	Duration MetPow	Mmin	Duration Mmin	HSR	Duration HSR	Sprint	Duration Sprint	HMLD	Duration HMLD
CD	15		0.33 ± 0.62**	0.4 ± 0.77**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.2 ± 0.41	0.22 ± 0.45	0 ± 0	0 ± 0	0.13 ± 0.35	0.14 ± 0.37
WD	12		0.25 ± 0.45*	0.36 ± 0.65**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
MID	6	MD+1 R	0.6 ± 1.34	1.08 ± 2.41	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.2 ± 0.45	0.21 ± 0.47	0 ± 0	0 ± 0	0 ± 0	0 ± 0
OMID	7		0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.17 ± 0.41	0.17 ± 0.42	0 ± 0	0 ± 0	0 ± 0	0 ± 0
FW	8		0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.13 ± 0.35	0.13 ± 0.37	0 ± 0	0 ± 0	0 ± 0	0 ± 0
CD	12		0.33 ± 0.82**	0.37 ± 0.91**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.33 ± 0.52	0.355 ±0.55	0.17 ± 0.41	0.18 ± 0.45	0 ± 0	0 ± 0
WD	9		0.92 ± 1.78	1.42 ± 2.96	0.08 ± 0.29	0.09 ± 0.31	0.08 ± 0.29	0.09 ± 0.32	0.42 ± 0.51	0.72 ± 1.25	0.17 ± 0.39	0.42 ± 1.18	0.33 ± 0.49	0.43 ± 0.68
MID	6	MD+1 C	1.89 ± 2.52	2.96 ± 4.02	0.22 ± 0.44	0.28 ± 0.56*	0.11 ± 0.33	0.16 ± 0.49	0.33 ± 0.71	0.5 ± 1	0.33 ± 0.5	0.64 ± 1.18	0.22 ± 0.44	0.38 ± 0.76
OMID	4		2.5 ± 5	4.45 ± 8.9	0.5 ± 0.58	0.56 ± 0.66	0.25 ± 0.5	0.41 ± 0.81	0.5 ± 0.58	0.78 ± 1	0.25 ± 0.5	1.3 ± 2.61	0.25 ± 0.5	0.5 ± 1
FW	6		0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.25 ± 0.5	0.26 ± 0.52	0 ± 0	0 ± 0	0 ± 0	0 ± 0
CD	58		2.33 ± 1.83**	3.71 ± 3.33*	0.22 ± 0.62**	0.41 ± 1.33**	0.41 ± 0.8**	1.39 ± 2.83**	0.29 ± 0.62	0.76 ± 1.74	0.21 ± 0.45	0.66 ± 1.52	0.29 ± 0.77	0.85 ± 2.36
WD	43		1.93 ± 1.78*	2.86 ± 2.92	0.02 ± 0.15*	0.03 ± 0.17*	0.09 ± 0.37**	0.17 ± 0.74**	0.12 ± 0.5	0.27 ± 1.26	0.09 ± 0.29	0.21 ± 0.7	0.07 ± 0.34	0.20 ± 1.11
MID	21	MD-4	3.1 ± 2.88	4.73 ± 4.58	0.24 ± 0.77**	0.32 ± 1.03**	0.29 ± 0.78**	0.59 ± 1.55**	0.29 ± 0.78	0.93 ± 3.14	0.19 ± 0.40	0.55 ± 1.24	0.33 ± 0.91	0.94 ± 3.17
OMID	26		4.62 ± 2.38	8.76 ± 5.47	0 ± 0**	0 ± 0	0.08 ± 0.27**	0.1 ± 0.35**	0.19 ± 0.63	0.41 ± 1.53	0.15 ± 0.37	0.4 ± 0.98	0.15 ± 0.61	0.66 ± 2.46
FW	40		1.68 ± 1.58	2.33 ± 2.39	0 ± 0**	0 ± 0	0.08 ± 0.35**	0.18 ± 0.87**	0.2 ± 0.61	0.47 ± 1.44	0.08 ± 0.27	0.11 ± 0.39	0.15 ± 0.58	0.51 ± 1.94
CD	65		4.22 ± 2.8	7.2 ± 5.45	0.18 ± 0.43**	0.22 ± 0.52**	0.34 ± 0.62**	0.4 ± 0.75**	0.18 ± 0.39	0.27 ± 0.64	0.31 ± 0.53	0.93 ± 1.69	0.09 ± 0.29	0.10 ± 0.32*
WD	51		3.29 ± 2.4	5.43 ± 4.81	0.06 ± 0.24**	0.07 ± 0.29**	0.04 ± 0.2**	0.0 ± 0.27**	0.04 ± 0.2	0.08 ± 0.42*	0.24 ± 0.47	0.4 ± 0.9	0.02 ± 0.14	0.02 ± 0.15*
MID	25	MD-3	4.04 ± 3.8	7.59 ± 7.15**	0.24 ± 0.52**	0.29 ± 0.62**	0.28 ± 0.54**	0.34 ± 0.66**	0.28 ± 0.46	0.38 ± 0.71	0.44 ± 0.51	1.32 ± 1.68	0.08 ± 0.28	0.09 ± 0.30
OMID	32		6.66 ± 3.4	11.93 ± 7.33*	0.03 ± 0.18*	0.03 ± 0.18*	0.13 ± 0.49**	0.15 ± 0.58**	0.13 ± 0.34	0.19 ± 0.54	0.41 ± 0.61	0.77 ± 1.19	0 ± 0	0 ± 0
FW	50		2.6 ± 2.08	3.65 ± 3.3	0.08 ± 0.27**	0.09 ± 0.33**	0.15 ± 0.5**	0.19 ± 0.64**	0.08 ± 0.27	0.09 ± 0.3	0.08 ± 0.27	0.1 ± 0.37	0.02 ± 0.14	0.02 ± 0.15*

n: individual records, same position significant differences with MD in post hoc test. *: $p < .05$, **: $p < .001$

Table 2 (Continuation)
Mean and Standard Deviation for each of the Day Types by Position.

Position	*n*		AccDens	Duration Acc Dens	MetPow	Duration MetPow	Mmin	Duration Mmin	HSR	Duration HSR	Sprint	Duration Sprint	HMLD	Duration HMLD
CD	61		1.59 ± 1.37**	2.59 ± 2.36**	0.18 ± 0.62**	0.24 ± 0.8**	0.16 ± 0.58**	0.3 ± 0.98**	0.02 ± 0.13	0.08 ± 0.63	0.02 ± 0.13	0.05 ± 0.42	0.02 ± 0.13	0.08 ± 0.63*
WD	50		1.14 ± 1.05**	1.58 ± 1.56**	0.02 ± 0.14*	0.04 ± 0.26**	0.02 ± 0.14**	0.04 ± 0.25**	0 ± 0	0 ± 0	0.02 ± 0.14	0.04 ± 0.27*	0.02 ± 0.14	0.03 ± 0.19*
MID	22	MD-2	1.86 ± 1.42	2.66 ± 2	0.05 ± 0.21**	0.06 ± 0.3**	0.09 ± 0.29**	0.11 ± 0.37**	0.05 ± 0.21	0.05 ± 0.22	0.05 ± 0.21	0.09 ± 0.42	0 ± 0	0 ± 0
OMID	30		2.7 ± 1.7	3.91 ± 2.92	0.03 ± 0.18*	0.04 ± 0.2*	0.13 ± 0.35**	0.18 ± 0.47**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
FW	48		0.88 ± 1**	1.27 ± 1.59**	0 ± 0**	0 ± 0	0.02 ± 0.14**	0.02 ± 0.16**	0.04 ± 0.2	0.08 ± 0.39	0.04 ± 0.2	0.08 ± 0.39	0.02 ± 0.14	0.04 ± 0.28*
CD	62		0.71 ± 0.99**	1.11 ± 1.58**	0.04 ± 2	0.05 ± 0.25	0.06 ± 0.24**	0.08 ± 0.34**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
WD	54		1.23 ± 1.24**	1.89 ± 2**	0 ± 0*	0 ± 0*	0.06 ± 0.30**	0.07 ± 0.37**	0.02 ± 0.13	0.02 ± 0.17*	0.05 ± 0.21	0.12 ± 0.53	0.02 ± 0.13	0.02 ± 0.17*
MID	24	MD-1	0.8 ± 1.05*	1.32 ± 2.07*	0.02 ± 0.14**	0.03 ± 0.21**	0.06 ± 0.41**	0.08 ± 0.59**	0.04 ± 0.19	0.06 ± 0.3	0 ± 0	0 ± 0	0.02 ± 0.14	0.03 ± 0.19
OMID	31		0.96 ± 1.04**	1.23 ± 1.37**	0.04 ± 0.2*	0.04 ± 0.21*	0.04 ± 0.20**	0.05 ± 0.25**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
FW	51		1.97 ± 1.58**	2.99 ± 2.42**	0.03 ± 0.18**	0.04 ± 0.2**	0.06 ± 0.36**	0.09 ± 0.51**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
CD	37		4.65±3	5.41 ± 5.158	2.62 ± 2.0	3.42 ± 2.73	3.11 ± 2.71	4.11 ± 3.65	0.24 ± 0.49	0.41 ± 0.86	0.22±0.42	0.42 ± 0.81	0.43 ± 0.8	0.59 ± 1.09
WD	21		3.86±2.2	4.508±3.387	1.62 ± 1.91	2.05 ± 2.35	1.90 ± 1.95	2.61 ± 3.03	0.48 ± 0.60	0.77 ± 0.97	0.43±0.81	0.82 ± 1.56	0.67 ± 0.97	0.95 ± 1.40
MID	17	MD	3.18±1.24	3.649±2.029	4.94 ± 3.03	6.49 ± 3.95	4.76 ± 2.77	6.14 ± 3.5	0.29 ± 0.47	0.43 ± 0.71	0.18±0.53	0.35 ± 1.04	0.41 ± 0.62	0.51 ± 0.77
OMID	10		5.1 ±2.96	6.877±4.638	2.2 ± 1.14	3.11 ± 1.43	3.4 ± 1.78	4.95 ± 2.17	0.3 ± 0.48	0.41 ± 0.69	0.1 ±0.32	0.2 ± 0.62	0.5 ± 0.71	0.67 ± 0.95
FW	23		3.13±1.14	3.363±1.886	3.74 ± 2.36	4.54 ± 2.87	4.74 ± 2.85	6.11 ± 3.78	0.35 ± 0.88	0.54 ± 1.34	0.35±0.49	0.64 ± 0.91	0.48 ± 0.67	0.65 ± 0.92

n: individual records, same position significant differences with MD in post hoc test. *: $p < .05$, **: $p < .001$

The number of SubMIP events and their duration was higher in MD for MetPow [number of events compared to MD+1C ($p < .001$; ES = 4.182), MD-4 ($p < .001$; ES = 4.541), MD-3 ($p < .001$; ES = 4.22), MD-2 ($p < .001$; ES = 4.739), MD-1 ($p < .001$; ES = 6.143) and between MD-1 and MD-3 ($p < .001$; ES = –1.922) also in their duration in comparison MD with MD+1C ($p < .001$; ES = 3.694), MD-4 ($p < .001$; ES = 3.605), MD-3 ($p < .001$; ES = 3.71), MD-2 ($p < .001$; ES = 3.961), MD-1 ($p < .001$; ES = 5.344) and between MD-1 and MD-2 ($p < .05$; ES = –1.383), MD-3 ($p < .05$; ES = –1.634) and MD-4 ($p < .05$; ES = –1.739)]. Mmin [number of events comparing MD with MD+1C ($p < .001$; ES = 4.379), MD-4 ($p < .001$; ES = 3.158), MD-3 ($p < .001$; ES = 3.319), MD-2 ($p < .001$; ES = 4.013), MD-1 ($p < .001$; ES = 4.355), and between MD-1 and MD-3 ($p < .05$; ES = –1.036), MD-4 ($p < .05$; ES = –1.196) and MD-2 compared with MD-4 ($p < .05$; ES = –0.854) also in their duration comparing MD with MD+1C ($p < .001$; ES = 4.182), MD-4 ($p < .001$; ES = 4.541), MD-3 ($p < .001$; ES = 4.22), MD-2 ($p < .001$; ES = 4.739), MD-1 ($p < .001$; ES = 6.143) and comparing MD-1 and MD-3 ($p < .05$; ES = –1.922)] for the variable HMLD [(number of events compared MD to MD+1R ($p < .05$; ES = 3.902), MD-4 ($p < .001$; ES = 1.412), MD-3 ($p < .001$; ES = 3.421), MD-2 ($p < .001$; ES = 5.573), MD-1 ($p < .001$; ES = 5.675) also comparing MD-1 to MD-4 ($p < .001$; ES = –4.262) and MD+1C ($p < .001$; ES = –4.299), MD-2 compared with MD-4 ($p < .001$; ES = –4.16) and MD+1C ($p < .001$; ES = –4.197) and the comparison of MD-3 to MD-4 ($p < .001$; ES = –2.009) and MD+1C ($p < .001$; ES = –2.046) also in their duration, MD to MD+1R ($p < .001$; ES = 2.947), MD-3 ($p < .001$; ES = 2.565), MD-2 ($p < .001$; ES = 3.096), MD-1 ($p < .001$; ES = 3.975) also differences found comparing MD-1 to MD+1C ($p < .001$; ES = –3.18) and MD-4 ($p < .001$; ES = –3.848), MD-2 compared with MD+1C ($p < .001$; ES = –2.3) and MD-4 ($p < .001$; ES = –2.968), MD-3 to MD+1C ($p < .001$; ES = –1.769) and MD-4 ($p < .001$; ES = –2.437) and MD-4 compared with MD+1R ($p < .05$; ES = 2.819)] (Figure 1).

Differences were found between MD and with respect to practically all training days in number of events for AccDens. Compared with [MD+1C ($p < .001$; ES = 0.79), MD+1R ($p < .001$; ES = 1.904), MD-4 ($p < .001$; ES = 0.332), MD-2 ($p < .001$; ES = 0.736) and MD-1 ($p < .001$; ES = 0.969). In duration of these MD events with respect to MD+1C ($p < .05$; ES = 0.418), MD+1R ($p < .001$; ES = 1.325), MD-3 ($p < .001$; ES = –0.192), MD-2 ($p < .001$; ES = 0.406) and MD-1 ($p < .001$; ES = 0.558)]. No differences were found in AccDens number of MD events with respect to MD-3 and duration of events in MD with respect to MD-4. There were also differences in this same variable in the number of events between MD-3 and the rest of the training days [MD+1C ($p < .001$; ES = 0.786), MD+1R ($p < .001$; ES = 1.9), MD-4 ($p < .001$; ES = 0.327), MD-2 ($p < .001$; ES = 0.732), MD-1 ($p < .001$; ES = 0.965) and between MD-4 and MD-1 ($p < .001$; ES = 0.637), MD-2 ($p < .001$; ES = 0.404), MD+1R ($p < .001$; ES = 1.572) and MD+1C ($p < .001$; ES = 0.458)], also between MD-1 [to MD-2 ($p < .001$; ES = –0.233) and MD+1R ($p < .001$; ES = 0.934), MD-2 to MD+1R ($p < .001$; ES = 0.1.16) and MD+1C to MD+1 R ($p < .001$; ES = 1.113)]. Finally, differences were found between the duration of the AccDens events between MD-3 and the rest of the days [MD+1C ($p < .001$; ES = 0.611), MD+1R ($p < .001$; ES = 1.518), MD-4 ($p < .001$; ES = 0.263), MD-2 ($p < .001$; ES = 0.598) and MD-1 ($p < .001$; ES = 0.751), also between MD-4 and MD+1C ($p < .001$; ES = 0.348), MD+1R ($p < .001$; ES = 1.254), MD-2 ($p < .001$; ES = 0.335) and MD-1 ($p < .001$; ES = 0.487), comparing MD-1 with MD-2 ($p < .001$; ES = –0.152) and MD+1R ($p < .001$; ES = 0.767), MD-2 with MD+1R ($p < .001$; ES = 0.919) and MD+1C to MD+1R ($p < .001$; ES = 0.906)] (Figure 1).

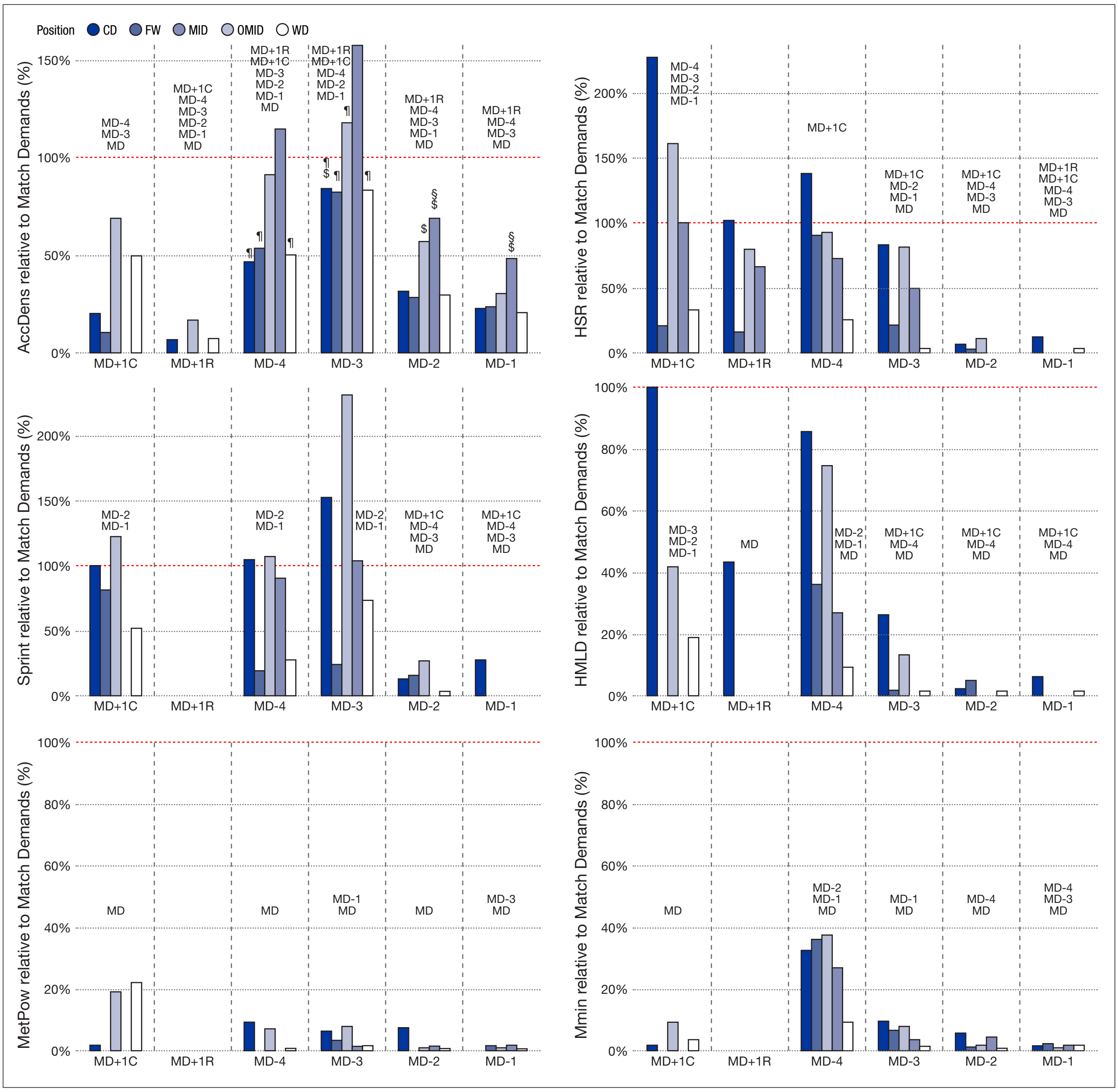
Regarding the number of events and duration of these events in the HSR variable, significant differences were found in the comparison of the MD days with respect to MD-3 ($p < .001$; ES = 1.271), MD-2 ($p < .001$; ES = 3.887) and MD-1 ($p < .001$; ES = 4.303) in number of events and to MD-3 ($p < .001$; ES = 0.992), MD-2 ($p < .001$; ES = 2.415), MD-1 ($p < .001$; ES = 3.15) and MD+1R ($p < .05$; ES = 1.441) in their duration (Figure 1). Also between MD-1 with respect to MD-4 ($p < .001$; ES = –3.772), MD-3 ($p < .05$; ES = –3.032), MD+1C ($p < .001$; ES = –4.513) and MD+1R ($p < .001$; ES = –2.822), between MD-2 in comparison with MD-3 ($p < .05$; ES = –2.616) , MD-4 ($p < .001$; ES = –3.356) and MD+1C ($p < .001$; ES = –4.097) and comparing MD-3 with MD+1C ($p < .05$; ES = –1.480) in number of events. Regarding the duration of the events significant differences were found comparing MD-1 with respect to MD-4 ($p < .001$; ES = –3.291), MD-3 ($p < .05$; ES = –2.158) and MD+1C ($p < .001$; ES = –3.358), between MD-2 in comparison with MD-3 ($p < .05$; ES = –1.423), MD-4 ($p < .001$; ES = –2.556) and MD+1C ($p < .001$; ES = –2.624), between MD-3 with MD-4 ($p < .001$; ES = –1.133) and MD+1C ($p < .001$; ES = –1.2) also significant differences were found comparing MD+1R with MD-4 ($p < .05$; ES = 1.582), and MD+1C ($p < .05$; ES = –1.649) (Figure 1).

For Sprint, significant differences in number of events and duration were found between MD with respect to MD-1 ($p < .001$; ES = 4.528, $p < .001$; ES = 2.607) and MD-2 ($p < .001$; ES = 3.193, $p < .001$; ES = 1.577), between MD-1 in comparison with MD-3 ($p < .001$; ES = –4.499, $p < .001$; ES = –2.803), MD-4 ($p < .001$; ES = –3.831, $p < .001$; ES = –2.46) and MD+1C ($p < .001$; ES = –4.098, $p < .001$; ES = –2.497) and comparing MD-2 with MD-3 ($p < .001$; ES = –3.163, $p < .001$; ES = –1.773), MD-4 ($p < .001$; ES = –2.496, $p < .001$; ES = –1.43) and MD+1C ($p < .05$; ES = –2.762, $p < .001$; ES = –1.467).

Based on the post hoc analysis used to determine the differences between MD and same position for events in the AccDens variable, significant differences were observed between CD in MD+1C, for MD+1R significant differences were found in CD, WD and FW, in MD-4 for CD and WD, in MD-2 for CD, WD and FW and in MD-1 for all positions (Table 1). For MetPow variable significant differences were found on all days for all positions except on days MD+1 and on MD-1 for CDs. For the MMin variable, significant differences were found for all days and for all positions except for days MD+1. No significant differences were found for any position in the high-speed variables (HSR and Sprint) nor for HMLD respect MD and any of the training days.

In the analysis of the positions and training days, only the AccDens variable showed significant differences between positions for the same training day. Notably, OMID exhibited significant differences compared to WD and forwards FW on MD-1 ($p < .05$; ES = 0.712, $p < .001$; ES = 0.807) and MD-2 ($p < .001$; ES = 0.679, $p < .001$; ES = 0.93). On MD-3, OMIDs differed significantly from CD ($p < .001$; ES = 0.359), WD ($p < .001$; ES = 0.553), MID ($p < .05$; ES = 0.344), and FW ($p < .001$; ES = 0.678), and on MD-4, from CD ($p < .001$; ES = 0.539), WD ($p < .001$; ES = 0.686), and FW ($p < .001$; ES = 0.63). Additionally, on MD-3, CD showed significant differences when compared to FW ($p < .05$; ES = 0.318).

Figure 1
% of SubMip Events in Relation to the Competition.



*Significant differences (p<.05 based on Bonferroni Post-Hoc) in SubMip events between: Day type and positions within the same day type. * CD, $: FW, #: MID, $: OMID, §: WD*

Discussion

The objectives of this study were (a) to determine the conditional demands of external load based on the SubMIP periods during the competitive micro-cycle, (b) to compare the number and duration of SubMIP events demanded in the different sessions carried out in the competitive micro-cycle and, additionally, (c) to compare these demands based on the SubMIP depending on the specific position occupied by the football players during the competitive micro-cycle. The main findings of the study were the existence of significant differences in each of the variables between training days/competition matches and positions based on the SubMIP analysis (number of events and time above threshold). Values exceeding 50% of those shown in competition were noted. This was especially evident in HSR, Sprint, AccDens, and HMLD, observed across various days of the micro-cycle, in number of events and in time above the sub-maximal threshold. Values were also shown in much lower ranges (< 15 %) than those of the competition in the number of events and time above the threshold determined in the Mmin and MetPow variables.

The study of sub-maximal intensity periods in competitive matches is a novel subject (Caro et al., 2022). However, any differences in the characteristics of these periods between competitive matches and the various training sessions during the competitive micro-cycle remain largely unknown.

When analyzing the SubMIP of high-speed variables like HSR or Sprint, results demonstrated values similar (without significant differences) to competition for all positions in various training sessions. For the HSR variable on MD+1C and MD-4 sessions, no significant differences were found in relation to competition. In the case of the Sprint variable, no significant differences were noted compared to competition during MD+1C, MD-4, and MD-3 sessions. Unlike previous studies that examined men's and women's football absolute and/or relative load values in these variables (Martin-Garcia et al., 2018; Oliva-Lozano et al., 2022), reporting values from 45 % to 65% of high-speed meters on the training days with the highest stimulation of this variable (MD-4 and MD-3), compared to competition. These findings suggest players can replicate sub-maximal efforts made in competition in HSR and Sprint variables across training sessions.

Moreover, during MD+1R sessions, SubMIP events accumulated for HSR variable, despite these sessions being aimed at athletes' recovery. This accumulation is influenced by the design of this session type, which includes progressive runs up to 70 % of subjective maximum speed with short recovery (five progressive 40-meter runs with a 40" rest between series). This repetitive action in a short time frame impacts this variable, especially for players whose MIP for HSR is not high, easily reaching 85 % (Caro et al., 2022). This observation could explain why CDs show values exceeding 80 % of competition demands and MIDs approach 50 % in the number of HSR SubMIP events during MD+1R sessions, whereas WDs record no events in the same drill. These findings underline the significance of acknowledging different profiles, based on various MIP and SubMIP relationships. These relationships are determined by individual MIP values and the specific physical demand of the position.

Differences were also observed in the SubMIP analysis relative to competition demands in variables such as MetPow and Mmin. During the micro-cycle, these variables displayed lower values, peaking at only 15 % of the competition levels on the days with the highest training load (MD-4 and MD-3), in both event count and duration. This contrasts with the analysis by values relative to competition (> 50 %) on days of highest training load (MD-4 and MD-3) (Chena et al., 2021; Martin-Garcia et al., 2018). It is important to note that the MetPow and Mmin variables, along with AccDens, present higher SubMIP values in competition, as shown in Caro et al. (2022).

Contextualizing analyses in relation to the nature of the variables, the differences found between continuous variables like AccDens, Mmin or MetPow, and high-speed variables or HMLD that are only displayed when the player exceeds each of their respective thresholds, are worth noting. As seen earlier, variables like AccDens, Mmin or MetPow are more prevalent during competition (Caro et al., 2022) but show lower percentages during training sessions. It could be understimulating players in variables such as Mmin and MetPow, these variables show significant differences in all training compared to competition. The nature of the variable and its connection to the training task can elucidate events that occur in MD+1R, where significant HSR values are achieved with only a few sub-maximal intensity progressive runs, yet not a single Mmin or MetPow event is recorded.

Days before competition (MD-1 and MD-2) displayed lower values in relation to the player's maximum individual percentage (referring to competition), thus adhering to the trend reflected during the competitive micro-cycle when more "classic" analyses are conducted (Chena et al., 2021; Diaz-Seradilla et al., 2022; Oliva-Lozano et al., 2022). This trend might be influenced by the intentional reduction of training load usually done prior to competition (Oliva-Lozano et al., 2022), which, as our study results show, also appears in relation to SubMIP periods. A study in futsal showed, based on high- and very-high intensity scenarios, that the most demanding day was MD-2 in various variables (Illa et al., 2020b). Given that futsal is a different sport with distinct conditional demands and potentially different load distributions, direct comparisons between studies might not be entirely relevant. However, to our knowledge, this is the only study that addresses the topic of SubMIP during a competitive micro-cycle in a team sport.

In terms of positional analysis, previous research that examined various external load variables in both absolute and relative terms has shown differences between player positions during competitive micro-cycles variables (Diaz-Seradilla et al., 2022; Martin-Garcia et al., 2018). This contrasts with the findings from studies focused on SubMIP periods. The SubMIP periods appear to be influenced by the nature of the data, which are individualized according to the competitive profile. Therefore, a specific stimulus of the sport during training will do events are distributed relatively uniformly across all positions. The only difference observed between positions was in the AccDens variable.

This study has some limitations. Results derive from a single team with a specific work methodology, examining micro-cycles that included only one match and had a similar structure. To assert that this study's results can be generalized to other contexts, more research in this direction should be conducted, as there is no related literature to our knowledge. Likewise, the sample size could be expanded to corroborate the identified differences. A significant limitation of this study is the interpretation of variables that exhibited averages of zero and a standard deviation of zero on MD+1R days. In these instances, no significant differences were observed, which could be due to the lack of variability in the data. This phenomenon presents a methodological challenge, as the complete lack of variability (with all values being zero) restricts the capacity of statistical analyses to identify significant differences.

Conclusions

This study demonstrated significant differences between training sessions and competition matches during a competitive micro-cycle when analyzed using SubMIP. Significant differences were found between training days in certain variables, particularly in AccDens and Sprint, as well as notable differences between competition and various training days in MetPow, Mmin, and HMLD (in some of the analyzed positions).

Lastly, differences were found between training days, positions, and competition. In some cases, the results of this study diverge from those obtained in previous research that used relative values in comparison to competition. This suggests that the current approach to training load control analysis may be incomplete.

Practical Applications

The differences shown between the results of SubMIPs and other load quantification methods underscore the need to find new alternatives for load control in team sports.

This study introduces a novel perspective for the analysis of training and competition load. SubMIP analysis can be a valuable complement to the analysis methods currently in use, especially due to its approach to the intermittent nature of team sports.

During training sessions conducted in the competitive micro-cycle of a match, players appear understimulated in variables such as MetPow, Mmin, and HMLD from a SubMIP event perspective. This raises questions about the necessity of accumulating certain SubMIP event values in specific variables during the competitive micro-cycle for effective competition.

Analyzing maximum intensity periods could give insights into a singular maximum demand event occurring during sessions/matches (Caro et al., 2022; Gabbett et al., 2016). Associating intensity solely with these peak events might lead to an oversight of the effects of intermittent variable intensity efforts (such as maximum, sub-maximal, moderate, and pauses) on athlete fatigue (Carling et al., 2019; Johnston et al., 2014). In this context, game phases with high intensity, even if not reaching match peak, should be a key training focus, as they may relate to match fatigue accumulation and adaptive processes pursued in training sessions. However, it should be noted that the SubMIP threshold directly relates to the player's individual MIP, which is decisive in results and their interpretation.

Given the existing uncertainties in determining the optimal workload throughout the week (coupled with the importance of understanding the nature of the data), new lines of research are opened to establish SubMIP as a valid and reliable tool for training load control.

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