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IN-SEASON EXTERNAL TRAINING LOAD OF PROFESSIONAL SOCCER PLAYERS: DOES IT AFFECT MATCH RUNNING PERFORMANCE?

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Original research:

Abstract

It is often hypothesized that in-season weekly distribution of external training load (ETL) is an important determinant of match running performance (MRP) in soccer. However, studies rarely examined associations between ETL and MRP including comparison of training days within weekly microcycles. This study aimed to (i) evaluate ETL of professional soccer players during the in-season, (ii) determine association between daily ETL and MRP. The ETL and MRP of professional soccer players (n=21) were measured by global positioning system during the trainings and matches in season 2020/21 of highest national soccer competition in Croatia. Variables included the total distance covered; the distance covered by low intensity running, running, and high intensity running; total and high-intensity accelerations; total and high-intensity decelerations. Differences in ETL among training days were analysed by repeated-measures ANOVA and Scheffe post-hoc. Pearson's correlations were used to determine the association between ETL and MRP. Calculations were examined separately for each training session within in-season microcycles (categorized as days before the match day, i.e., MD minus). All ETL variables were significantly lower on MD-1 and MD-2 than on MD-3 and MD-4 (F-test: from 25.31 to 62.03; all $p<0.01$; all large effect sizes). Running, high intensity running, total accelerations and decelerations on MD-1 sessions were positively correlated with corresponding running performances from matches (all moderate correlations, $p<0.05$). This study demonstrated that training load one day before match may determine game pace of professional soccer players in the subsequent match.

Keywords: monitoring, weekly load, match demands, football, physical demands

Introduction

Match running performance (MRP) in soccer has been extensively researched in last decade what ultimately led to their better understanding (Barrera, Sarmento, Clemente, Field, & Figueiredo, 2021; Paul, Bradley, & Nassis, 2015). Today is well known that soccer player can cover between 9 and 14km during the matches, performing 5 – 15% of that distance in high intensity running (Andrzejewski, Chmura, Pluta, & Konarski, 2015; Valter Di Salvo, Gregson, Atkinson, Tordoff, & Drust, 2009; Modric, Versic, Sekulic, & Liposek, 2019). To successfully cope with such match demands, the physical conditioning of the players has become an indispensable component of soccer training programs (Andrzejewski, Konefał, Chmura, Kowalczuk, & Chmura, 2016).

Basically, soccer training programs are designed to enable players to achieve an appropriate conditioning status, prevent injuries, and compete at the highest possible level during the season (Jaspers, Brink, Probst, Frencken, & Helsen, 2017). For such purposes, training programs need to be able to be modified so that they are optimally individualized and that, consequently, players' match performance is maximized (Castagna, Chamari, Stolen, & Wisloff, 2005). Thus, proper and continuous monitoring of the training load is important to determine the applied training load and implement interventions in subsequent sessions (i.e., increases or decreases in the training load (Jaspers et al., 2017; Modric, Versic, & Sekulic, 2020a; Rebelo et al., 2012).

Training load consists of both external (ETL) and internal (ITL) training load. The ETL, referring to the physical work undertaken during exercise, is typically evaluated with measures obtained from GPS or video-based technologies (i.e., total distance covered, different speed zone distance covered, accelerations and decelerations) (Modric, Versic, & Sekulic, 2021b; Scott, Lockie, Knight, Clark, & de Jonge, 2013). The ITL, related to the physiological and psychological stresses imposed on the player's body, is often quantified using heart rate (HR) telemetry and rating of perceived exertion (RPE) (Jaspers et al., 2017)., Due to the limited sensitivity of HR to detect sudden

movement changes during intermittent exercise and subjective nature of RPE monitoring (Swallow, Skidmore, Page, & Malone, 2021), ETL is most often quantified for a comprehensive understanding of the soccer training program implemented (Akenhead, Harley, & Tweddle, 2016; Modric et al., 2020a).

It is often hypothesized that in-season ETL is an important determinant of MRP in soccer. However, studies rarely examined associations between ETL and MRP, presenting inconsistent findings. In brief, Clemente et al. demonstrated trivial-to small correlations between the total weekly ETL and MRP in the first Portuguese league, suggesting that training was independent of the dynamics of the next match (Clemente et al., 2019). Recently, Silva et al. reported that only high-speed running (> 19.8km/) and high intensity accelerations (> 3m/s^2) in matches were correlated (both moderate correlations) with the corresponding training variables, showing limited influence of ETL on MRP in 3rd Portuguese league (Silva et al., 2021). On the other hand, Modric et al. reported moderate correlations for almost all running parameters obtained at training and matches in Croatian First Division, indicating reasonable influence of ETL on MRP (Modric, Versic, et al., 2021b). Interestingly, when analysis was conducted according to the playing positions, results did not indicate association between ETL and MRP for wide midfielders and forwards (Modric et al., 2020a).

Such inconsistencies in findings may be influenced by different training methodologies in different countries (Modric, Jelicic, & Sekulic, 2021). However, despite the fact that previously cited studies provided valuable information how total weekly ETL influence MRP in different leagues, detailed knowledge about this issue is still limited. In particular, there is a lack of studies which investigated association between ETL and MRP including comparison of training days within weekly microcycles. We were of the opinion that this topic is important to study to determine understanding as to how ETL distribution within microcycle affect MRP. Findings from such study can be used to improve the training process what may consequently increase the team performance in the matches. Therefore, this study aimed to (i) evaluate ETL distribution of professional soccer players during the in-season microcycle, (ii) determine association between daily ETL and MRP.

Methods

Participants and Design

Twenty-one professional soccer players (M ± SD, age 24.19 ± 2.46, body mass 77.32 ± 4.45, height 182.32 ± 6.32) from the same team participated in this study. Six of them were central midfielders (CM), four were central defenders (CD), four were forwards (FW), three were fullbacks (FB), and two were wide midfielders (WM). Goalkeepers were excluded due to the specificity of their role. All the players approved the use of training and match data for the purpose of the present study by written consent.

An observational cohort study was implemented on a professional soccer team during a full 2020/2021 season of the Croatian highest national soccer competition. All data were collected with the global positioning system (GPS) technique (see later for details) during in-season (i.e., competitive phase of the season) trainings and matches. We considered only those weeks in which three criteria were fulfilled: (i) the team played only one match in the week, (ii) there was minimum of 6 days between the matches, (iii) there was minimum of 4 training days in the week. This decision was made to reduce the variability among comparisons, as previously suggested (Clemente et al., 2019). In addition, due to methodological reasons, only players who played a whole match and participated in all training sessions in the week before each match were included in the study. These criteria reduced number of the analyzed matches from 36 (i.e., which is maximum number of matches in observed competition) to 14. Consequently, only training sessions that preceded analyzed matches were observed (n = 67), resulting in 87 observations which were used as cases for this study.

Training sessions were classified based on the number of days before the match day (i.e., MD minus) (Modric, Jelicic, et al., 2021). For example, MD-3 means that this session took place three days before the match day. Since training approaches were not constant first two days after the matches, we did not include ETL from MD-5 and MD-6 in analysis. On the other hand, training approaches were always similar in rest of the week, therefore we included ETL from only MD-4, MD-3, MD-2, and MD-1.

Procedures

Apart from players' age, body height, and body mass, variables in this study included two sets of running performance variables: running performance from matches (MRP) and from trainings (ETL).

Data were collected by 21 GPS devices (Vector S7, Catapult, Catapult Sports Ltd., Melbourne) with a sampling frequency of 10 Hz. The use of this tracking system has appeared in previous researches (Modric, Jelicic, et al., 2021). The reliability and validity of such system were previously confirmed (Johnston, Watsford, Kelly, Pine, & Spurrs, 2014). Each player

wore the same GPS device in all training sessions and matches in order to avoid inter-unit variability.

MRP was measured during official matches, while ETL was measured during all training sessions that the team participated in during the week and quantified according to the days that preceded official matches (Modric, Jelicic, et al., 2021). Both MRP and ETL included: the total distance covered (m), low-intensity running (<14.3 km/h), running (14.4–19.7 km/h), high-intensity running (>19.8 km/h), number (frequency) of total accelerations (>0.5 m/s^2), number of high intensity accelerations (>3 m/s^2); number of total decelerations (less than −0.5 m/s^2), and number of high-intensity decelerations (less than –3 m/s^2) (Modric, Jelicic, et al., 2021).

Statistics

Homogeneity was checked by the Levene's test. The normality of the distributions was confirmed by the Kolmogorov–Smirnov test, and data are presented as means ± standard deviations.

Differences in ETL among training days within microcycle were analysed by repeated-measures ANOVA and Scheffe post-hoc. To evaluate the effect sizes (ES), partial eta-squared values (η2) were presented (small ES: >0.02; medium ES: >0.13; large ES: >0.26) (Cohen, 2013).

Pearson's correlations were used to determine the association between ETL and MRP. Calculations were examined separately for each training session within in-season microcycles (categorized as days before the match day, i.e., MD minus), and interpreted as previously suggested: r ≤ 0.35 indicates a low or weak correlation, r = 0.36 to 0.67 indicates a modest or moderate correlation, r = 0.68 to 1.0 indicates a strong or high correlation, and r > 0.90 indicates a very high correlation (Taylor, 1990).

For all analyses, Statistica 13.0 (TIBCO Software Inc., Greenwood Village, CO, USA) was used, and $p < 0.05$ was applied.

Results

Table 1 present descriptive parameters and differences in ETL among different training days within microcycle. Results indicated significant differences for all ETL variables on different training days within microcycle (F-test: from 25.31 to 62.03; all p<0.01; all large effect sizes). Specifically, all ETL variables were lower on MD-1 and MD-2 (significant post hoc differences when compared to MD-3 and MD-4). Total distance, low intensity running, running, total accelerations and decelerations were greatest on MD-3 (significant post hoc differences when compared to all other training days), while high intensity running, high intensity accelerations and decelerations were greatest on MD-3 and MD-4 (significant post hoc differences when compared to MD-1 and MD-2).

Table 1. Descriptive statistics and differences in ETL among training days (data are given as Mean ± SD)

	MD-1	MD-2	MD-3	MD-4	F-test (p)	η2
Total distance	4079±579 [3,4]	4314±1095 [3,4]	6625±1160 [1,2,4]	5873±2086 [1,2,3]	55.10 (0.01)	0.46
Low intensity running	3611±506 [3,4]	3891±915 [3,4]	5527±864 [1,2,4]	4952±1668 [1,2,3]	47.17 (0.01)	0.42
Running	353±140 [3,4]	330±185 [3,4]	757±326 [1,2,4]	626±332 [1,2,3]	46.78 (0.01)	0.43
High intensity running	115±69 [3,4]	93±91 [3,4]	340±236 [1,2]	295±309 [1,2]	25.31 (0.01	0.28
Total accelerations	176±34 [3,4]	177±58 [3,4]	306±67 [1,2,4]	270±105 [1,2,3]	62.03 (0.01)	0.49
High intensity accelerations	10±6 [3,4]	9±6 [3,4]	22±10 [1,2]	21±16 [1,2]	36.10 (0.01)	0.36
Total decelerations	176±33 [3,4]	178±58 [3,4]	306±65 [1,2,4]	271±106 [1,2,3]	60.06 (0.01)	0.48
High intensity decelerations	9±4 [3,4]	9±5 [3,4]	21±10 [1,2]	22±13 [1,2]	48.14 (0.01)	0.43

Note: MD – match day; [1] significant post hoc differences to MD-1; [2] significant post hoc differences to MD-2; [3] significant post hoc differences to MD-3; [4] significant post hoc differences to MD-4; η2 – effect size

Table 2 presents the correlations between MRP and same variable on different training days within microcycle (e.g., corresponding variables/performance). All MRP variables were significantly correlated with corresponding variables obtained in the previous week on MD-1 (r = 0.25 – 0.44; all $p < 0.05$). High intensity running (r = 0.31) and high intensity decelerations (r = 0.43) on MD-2 were significantly correlated with corresponding variables from matches ($p < 0.05$). Small correlations were evidenced between total distance, low intensity running and running in matches and corresponding variables on MD-3 (r = 0.24, 0.30 and 0.31, respectively). Total and high intensity accelerations/decelerations on MD-4 were significantly correlated with corresponding variables from matches (r = 0.30 – 0.40; all $p < 0.05$).

Table 2. Associations between ETL and MRP on different training days (data are given as r)

	MD-1	MD-2	MD-3	MD-4
Total distance	0.25*	0.03	0.24*	0.19
Low intensity running	0.27*	0.05	0.30*	0.08
Running	0.35*	0.15	0.31*	0.21
High intensity running	0.44*	0.31*	0.02	0.14
Total accelerations	0.39*	0.13	0.21	0.30*
High intensity accelerations	0.31*	0.19	0.03	0.30*
Total decelerations	0.39*	0.10	0.19	0.32*
High intensity decelerations	0.25*	0.43*	-0.07	0.40*

*MD – match day; * denotes significant correlations at $p < 0.05$*

Discussion

This study aimed to evaluate ETL distribution of professional soccer players during the in-season microcycle and its possible association with MRP. Results indicated two important findings. First, significant differences in all ETL variables were evidenced on different training days within microcycle (all large effect sizes). Second, all ETL variables on MD-1 were significantly correlated with corresponding variables from matches ($p < 0.05$).

Previous studies which investigated distribution of ETL within in-season microcycles indicated differences in the distribution of training load between high-level soccer teams (Stevens, de Ruiter, Twisk, Savelsbergh, & Beek, 2017). Specifically, Stevens et al. reported the highest training load on the first training of the week for professional Dutch Eredivisie soccer players (Stevens et al., 2017). Studies involved English Premier League teams showed the highest training load on the second training of the week for (Akenhead et al., 2016; Anderson et al., 2016). In contrast, other studies involved English Premier League teams reported no differences in training load between the first 3 training sessions of the week (Malone et al., 2015).

Our results indicated that all ETL variables were greater on MD-4 and MD-3 than on MD-1 and MD-2. Specifically, total distance covered, low intensity running, running, high intensity running, total and high-intensity accelerations, total and high-intensity decelerations were significantly greater on the first and second trainings in the week (i.e., MD-4 and MD-3, respectively) than on trainings held two days before the match. Such increased ETL on MD-4 and MD-3 was almost certainly consequence of physical conditioning programs, which became an indispensable component in training practise of elite soccer players (Andrzejewski et al., 2016). On the other hand, decrease of ETL on MD-1 and MD-2 (i.e., lower values of all ETL variables) indicates that tapering strategies were applied two days before the match in order to maximize players' performance (Fessi et al., 2016). Altogether, these findings demonstrated that training programs of elite soccer players from Croatian First Division within in-season microcycles consist of development and tapering phase. Development phase lasting two days was characterized by grater values of all ETL variables, while tapering phase is implemented on last two days before the match and was characterized by lower values of all ETL variables.

It has previously been reported that MRPs are determined by various factors such as playing position in the game, players' physical abilities, team's tactical formation, total weekly training load, match location, opponents' level or match outcome (Andrzejewski et al., 2016; Barrera et al., 2021; Chmura et al., 2021; Lago-Peñas, 2012; Modric, Versic, & Sekulic, 2020b, 2021a; Modric, Versic, et al., 2021b). Our study is one of the first which demonstrated that daily training load may determine MRP as well. Specifically, we evidenced moderate correlations between running, high intensity running, accelerations and decelerations on MD-1 and corresponding variables from the matches. Such results indicate reasonable influence of training load one day before the match on MRP in subsequent match.

It must be especially emphasized that we evidenced highest correlation for high intensity running ($r = 0.44$). Considering that amount of running at higher speeds determine game pace (i.e., game intensity), findings from our study indicate that training programs which utilize greater amount of high intensity running one day before the match may have important impact on game intensity in the subsequent match. According to the previous studies which revealed that high intensity running is one of the crucial elements of success in soccer (Andrzejewski, Chmura, Konefał, Kowalczuk, & Chmura, 2017; V Di Salvo et al., 2007), it seems that greater training intensity one day before the match may consequently positively reflect even on success in soccer. However, as this was not topic of our study, such considerations must be confirmed in future studies by analysing daily ETL and success in soccer.

When planning training intensity on MD-1 soccer coaches should be aware that high intensity running is related to anaerobic work which increases metabolic acidosis because of the increased H+ ion concentrations (Modric, Versic, et al., 2021a). Therefore, if high intensity running is not controlled, possible accumulation of H+ ions may inhibit enzymes essential to muscle contraction and decrease players abilities (Hall, 2010). Consequently, players performances may be limited on match day. To avoid it, we recommend that training intensity one day before the match should be stimulated by utilizing anaerobic

alactic work. Also, large resting periods between sets/exercises should be implemented to avoid overtraining effect.

Strengths and Limitations

The main limitation of this study is the fact that only one team was observed. However, this is a very common obstacle in studies involving professional and elite players (Stevens et al., 2017). Also, due to methodological reasons we included players only if they participated in full training sessions and the corresponding following matches.

This is the one of the first studies which quantified ETL distribution within in-season microcycles and analysed its influence on MRP, providing valuable knowledge of association between daily training load and match performances. Also, the data were collected during official games, among professional players, and at the highest national competitive level. Finally, the findings of this study may help soccer coaches to improve periodization of in-season microcycles, what can positively reflect on performances of whole team in the matches.

Conclusion

This study demonstrated that training programs of elite soccer players from Croatian first division within in-season microcycles consist of development and tapering phase. Development phase lasting two days was characterized by grater values of all ETL variables. On the other hand, in tapering phase players were experiencing two days before the match lower ETL in order to maximize their performances on match day.

In addition, results from this study indicated that training load one day before the match may determine game pace of professional soccer players in the subsequent match, especially in term of high intensity running. Such findings suggest that higher training intensity in sessions one day before the match may provoke higher game intensity. Achieving high training intensity one day before the match be should by utilizing anaerobic alactic work, while large rest periods between sets/exercises should be implemented.

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