Title:

Quantification of training and match load during non-congested and congested microcycles in academy football players: a UEFA Youth League team case study

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Title:

Quantification of training and match load during non-congested and congested microcycles in academy football players: a UEFA Youth League team case study

Abstract:

This study aimed to quantify and compare training and match load across non-congested and congested microcycles in academy football. Twenty-four under-19 Italian Serie A academy football players competing in national and international tournaments were monitored across a competitive season using external and internal load measures. Microcycles were classified either as non-congested (> 4 days between consecutive matches) or congested (≤ 4 days between consecutive matches). Load was analysed relative to match proximity: two days (MD-2), one day (MD-1) before the match and match day (MD). Linear mixed models and Cohen's *d* effect sizes were used for analysis. A significant microcycle type x training day interaction was observed for duration, total distance, session rating of perceived exertion (sRPE) and sRPE training load (sRPE-TL). On MD-2 duration, total distance, sRPE and sRPE-TL were significantly higher in non-congested compared to congested microcycles ($p < 0.05$, $d = 0.27$-1.01). On MD-1, total distance was significantly higher in non-congested compared to congested microcycles ($p < 0.001$, $d = 0.36$). No significant differences were observed on MD ($p > 0.05$, $d = -0.22$-0.20). Congested microcycles are characterised by reduced training volume, suggesting that training duration is adjusted to facilitate recovery in academy football players.

Keywords: monitoring, fixture congestion, periodisation, performance, team sports

Introduction:

Modern elite football players competing at the international level are increasingly exposed to growing match exposures and physical demands, resulting in congested schedules with limited time for rest and recovery between matches (Allen et al., 2025). For instance, world-class football players competing across domestic and international tournaments have been reported to accumulate more than 60 match appearances per season (FIFPRO, 2025). Fixture congestion, commonly defined as a minimum of two match appearances within 96 hours (i.e., ≤ 4 days) (Julian et al., 2020; Page et al., 2023), substantially influences training prescription and load management strategies across the competitive microcycle. Research in professional football shows that congested match periods affect training volume, intensity and periodisation of loading (Anderson et al., 2016; Barreira et al., 2024; Gómez-Díaz et al., 2024; Gualtieri et al., 2024). Increased match exposure, combined with accumulated fatigue, travel demands and limited recovery time, could elevate the risk of injury and illness (Morgans et al., 2014; Page et al., 2023) and be detrimental to physical performance in football players (Freitas et al., 2021). Collectively, these factors pose substantial challenges to players' performance and healths (Den Hollander et al., 2025).

A similarly congested match schedule is evident in youth academy settings, where high-level adolescent players frequently participate in multiple domestic and international tournaments throughout the competitive season, comprising club and national team commitments (Wilke et al., 2023). For instance, academy players from professional clubs competing in the UEFA Champions League also participate in the UEFA Youth League, a parallel international tournament for under-19 players (UEFA, 2013). This context requires adolescent players to sustain successive matches across national and international tournaments (e.g., three matches within eight days), with international competitions typically imposing greater match demands than domestic-level fixtures (Castellano et al., 2020). Although several studies have characterised external and internal training loads during typical (i.e., non-congested) microcycles comprising one match per week (Connolly et al., 2025; Coutinho et al., 2015; Franceschi et al., 2024; Hannon et al., 2021; Maughan et al., 2021), information on training and match loads during congested fixtures of high-level youth academy players remains limited.

This research addresses an important topic in the field of applied football science. A recent expert position statement on the professional match calendar has underscored the necessity for age-specific, evidence-informed workload safeguards in youth football to support player long-term development, performance, and health (Den Hollander et al., 2025). Examining training load characteristics across congested and non-congested microcycles has direct practical relevance for sport scientists and coaches supporting youth players' performance and development from the academy to the senior team environments, or from club to national team settings. Therefore, this study aimed to quantify and compare external and internal training and match loads during non-congested and congested microcycles in high-level academy football players.

Methods:

Subjects:

Twenty-four male outfield academy football players from the under-19 squad of an Italian Serie A club were recruited for this study (age: 18.1 ± 0.4 years; body mass: 76.1 ± 6.6 kg; height: 182.0 ± 7.6 cm). Players participated in national and international competitions and would be classified as highly trained (Tier 3: national level) or elite (Tier 4: international level) athletes based on a participant classification framework (McKay et al., 2022). Data collection was conducted as part of the club's routine performance monitoring programme. Written informed consent was obtained from all players and, where applicable, from their parents or legal guardians. The study was ethically approved by a University Research Ethics Committee (22/SPS/025) and was conducted in accordance with the Declaration of Helsinki.

Experimental Design:

Training and match load data were collected throughout a full competitive season during which players competed in national (i.e., Primavera 1 League, Primavera 1 Cup) and international (i.e., UEFA Youth League) tournaments. External load was quantified using global navigation satellite systems (GNSS), whereas internal load was assessed using session rating of perceived exertion (sRPE). Competitive microcycles were classified either as non-congested (i.e., consecutive match appearances separated by > 4 days) or congested (i.e., consecutive match appearances separated by ≤ 4 days) (Julian et al., 2020; Page et al., 2023) (Figure 1). For inclusion in the analysis, players were required to have completed all team training sessions within a given microcycle and a minimum of 70% of the competitive match. Given these inclusion criteria, training load data reflected the training activities performed by starting players, while compensatory training performed by non-starting players was not included in the present study. The periodisation of daily training loads was analysed relative to match day (MD) (Malone et al., 2015), comparing common day types in both congested and non-congested microcycles; two days before a match (MD-2), one day before a match (MD-1) and MD. Of the 24 players, 461 single microcycles (197 non-congested and 264 congested) were included in the final analyses.

*** Figure 1 ***

Procedures:

During all training sessions and competitive matches, external load was quantified using GNSS (Apex Pro Series, 10Hz, STATSports, Newry, Northern Ireland). This tracking system has demonstrated valid and reliable estimates of distance and velocity during team sports activities (Beato et al., 2023). The number of satellites acquired during training and match sessions ranged from 14 to 21, and the horizontal dilution of precision ranged between 0.3 and 0.6. GNSS data were collected, downloaded and analysed on Sonra software (version 4.1.31, STATSports, Newry, Northern Ireland), as described in detail elsewhere (Franceschi et al., 2024). Duration (min), total distance (m), high-speed running distance (> 20 $km \cdot h^{-1}$; m), sprinting distance (> 25 $km \cdot h^{-1}$; m), accelerations (> 3 $m \cdot s^{-2}$; count) and decelerations (< -3 $m \cdot s^{-2}$; count) were quantified. Internal load was quantified using the sRPE method employing Borg's category ratio 10 scale (Impellizzeri et al., 2004), with sRPE (arbitrary units, au) and sRPE training load (sRPE multiplied by session duration, au) included in the analysis. These measures were selected based on a framework for monitoring training load in youth football (Connolly et al., 2026).

Statistical Analysis:

Data are presented as mean and 95% confidence intervals (CIs). Linear mixed models were employed to estimate the differences in training load measures (dependent variables) across training days (MD-2, MD-1, MD) and microcycle type (non-congested, congested). Training days and microcycle types were modelled as fixed effects, whilst individual players were modelled as random effects. Estimated marginal means and 95% CIs were calculated. Bonferroni correction was applied to adjust for pairwise multiple comparisons. The magnitude of differences was computed using Cohen's *d* effect size. Effect size magnitudes were interpreted according to the following thresholds: < 0.20, trivial; 0.20–0.59, small; 0.60–1.19, moderate; 1.20–1.99, large; > 2.00, very large (Hopkins et al., 2009). Statistical significance was set at $p < 0.05$. All analyses were performed using JAMOVI statistical software (the jamovi project, version 2.3, Sydney, Australia).

Results:

Results are reported in Table 1 and Figure 2. . A significant interaction was observed between microcycle types and training days for duration ($F = 75.5$, $p < 0.001$), total distance ($F = 75.5$, $p < 0.001$), sRPE ($F = 75.5$, $p < 0.001$), and sRPE-TL ($F = 36.3$, $p < 0.001$). Conversely, no significant interactions were observed for high-speed running distance ($F = 2.8$, $p = 0.064$), sprinting distance ($F = 1.0$, $p = 0.359$), accelerations ($F = 0.8$, $p = 0.454$) and decelerations ($F = 0.6$, $p = 0.532$). Post-hoc analyses showed that duration ($p < 0.001$, $d = 1.01$), total distance ($p < 0.001$, $d = 0.46$), sRPE ($p = 0.002$, $d = 0.27$) and sRPE-TL ($p < 0.001$, $d = 0.82$) were significantly higher in non-congested microcycles compared to congested microcycles on MD-2. On MD-1, total distance ($p < 0.001$, $d = 0.36$) was significantly higher in non-congested microcycles compared to congested microcycles. No significant differences between microcycle types were observed on MD ($p > 0.05$, $d = -0.22$ to 0.20).

*** Table 1 ***

*** Figure 2 ***

Discussion:

This study aimed to quantify and compare training and match load across non-congested and congested microcycles in high-level youth academy football players competing in national and international tournaments across a competitive season. We found that microcycle type affected both external and internal load on MD-2, with significantly higher training loads (duration, total distance, sRPE and sRPE-TL) on non-congested compared with congested microcycles. On MD-1, significantly greater training volume were observed for total distance only across non-congested microcycles, whilst no significant differences in external or internal load were found on MD between microcycle types.

The present findings demonstrate that congested microcycles substantially influence training loads in high-level academy football players, with significantly lower external (duration, total distance) and internal load (sRPE, sRPE-TL) on MD-2 compared with non-congested microcycles. Similar loading patterns have been reported in professional adult soccer, with lower training loads sustained during shorter microcycles (Anderson et al., 2016; Gualtieri et al., 2024; Oliva-Lozano et al., 2022), and a greater proportion of available time allocated to recovery in preparation for subsequent matches. The management of training and recovery on the days between successive matches during congested fixtures is a key consideration for performance practitioners, as it aims to attenuate muscle damage, minimise injury risk, and optimise performance capacity for subsequent matches (Field et al., 2021). In this study, MD-2 sessions across congested microcycles occurred ~48 hours after the preceding match (i.e., two days post-match), with the observed reductions in training load possibly reflecting a strategy to promote post-match recovery in starting players. . Indeed, previous research has shown that academy football players experience prolonged recovery of physical performance and perceived muscle soreness 48 hours post-match (Franceschi et al., 2025) and that muscle damage and inflammation markers increase post-match during congested schedules, likely leading to greater accumulated fatigue (Wilke et al., 2023). Conversely, other external training load measures reflecting the high-intensity and intermittent nature of football (e.g., high-speed running distance, sprinting distance, accelerations and decelerations) were not substantially influenced by the microcycle type, with only small, non-significant differences observed across microcycle type. These findings suggest that, whereas training volume (e.g., duration and total distance) may be more directly manipulated during congested periods, the high-intensity demands of the MD-2 session were similar across microcycle types. Accordingly, careful training prescription of both volume and intensity remains essential to appropriately balance training stress and recovery within congested microcycles. Differences in training load between microcycle types tended to decrease on MD-1, with a significant reduction observed for total distance only. Previous research has demonstrated that a lower training volume on MD-1 (45 min vs 60-75 min) can increase players' readiness for the upcoming competition in youth football players (Douchet et al., 2022).

The present study also found no significant influence of microcycle type on the external and internal load sustained during match play. Nevertheless, examination of the magnitude of differences indicated small, non-significant effects for decelerations and sRPE between non-congested and congested microcycles. (Julian et al., 2020)Overall, the lack of significant differences between microcycle types suggests the complexities of the construct of match load, with external load sustained during MD providing information on the physical demands sustained by youth football players. These findings are consistent with the results of a meta-analysis on the effect of fixture congestion on the physical demands of match play, suggesting that a congested fixture scenario has no impact on total distance and may have a negative effect on moderate-intensity distances (Julian et al., 2020). Moreover, research on professional football players during international tournaments showed higher sRPE match load and subsequent worsened rating of perceived fatigue, muscle soreness and sleep duration with congested microcycles compared to other conditions (Noor et al., 2021). Within academy football environments, match demands in the UEFA Youth League have been shown to exceed those of domestic competition for total distance and high-speed running in under-19 Spanish football players during the most demanding passages of match play (Castellano et al., 2020). Accordingly, participation in international fixtures within congested schedules may result in greater perceived effort on youth academy players. This interpretation is partially supported by the small, non-significant increase in sRPE observed during congested microcycles in the present study, suggesting a potential increase in the internal load despite the comparable physical demands. With the increasing number of competitions in the international match calendar, future research is needed to establish whether specific player workload safeguards should be adopted to support long-term youth academy players' performance and health (Den Hollander et al., 2025).

Several limitations of this study warrant acknowledgement. First, intensity load measures (e.g., training load expressed per minute, maximal intensity periods) and other contextual factors that may influence training and match load (e.g., playing position, match location, travel distance associated with national and international competitions) were not included in the study design. Incorporating these variables in future research would provide a more comprehensive understanding of load management strategies during congested fixture periods. Second, this study quantified the training and match demands without assessing physiological and neuromuscular responses to load following congested fixtures. Future studies should therefore integrate both training load and training response measures to assess the effects of congested periods on physical performance and recovery in highly trained youth football players. Finally, training and match exposure with national teams were not included. Accounting for these data is necessary to fully characterise the seasonal demands and cumulative fixture congestion experienced by academy players competing at both club and international levels.

Conclusion:

This case study provides novel insights into the external and internal loads experienced by high-level youth football players across congested and non-congested microcycles. Training volume and sRPE training load were reduced on MD-2 during congested microcycles compared with non-congested microcycles, suggesting the importance of adjusting the load to prioritise recovery during congested fixture schedules. In contrast, match load was not substantially influenced by the preceding microcycle type, indicating that competitive demands were maintained irrespective of fixture congestion.

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Disclosure statement:

No potential conflict of interest was reported by the authors.

Figure captions

Figure 1. Schematic representation of non-congested and congested microcycles. Black boxes denote competitive matches, grey boxes represent training days, and white boxes denote recovery days; defined as either a rest day (i.e., day off) or a structured off-feet recovery day (i.e., combined recovery modalities including active recovery, massage and cold water immersion) without exposure to on-pitch activities. Abbreviations: MD: match day.

Figure 2. Magnitude of differences (Cohen's *d* effect size ± 95% CIs) of training and match load between non-congested and congested microcycles in under-19 Italian Serie A academy football players on MD-2, MD-1 and MD. A negative effect size indicates a higher training or match load on congested microcycles, while a positive effect size indicates a higher training or match load on non-congested microcycles. The grey areas represent the trivial effect size thresholds. Abbreviations: CIs: confidence intervals; MD: match day; sRPE: session rating of perceived exertion; TL: training load.

Table captions

Table 1. Training and match load during non-congested and congested microcycles in under-19 Italian Serie A academy football players. Data are reported as mean and 95% confidence intervals (CIs).

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