
Running head: Training Load in Academy Soccer

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Abstract

**Purpose:** The transition into full-time training represents a key period in the development of young soccer players. Here we compared the weekly training loads (matches, field-, and resistance-training) of English Premier-League Academy soccer players from under-16 (U16), under-18 (U18) and under-23 (U23) age-groups during a training meso-cycle. **Methods:** Forty players (U16 n= 13, U18 n= 15 and U23 n = 12) were monitored using global navigation satellite systems and differential ratings of perceived exertion (dRPE). External load metrics were total distance, high-speed running distance, (absolute: ≥19.8km·h⁻¹, relative: ≥87% of 30-15 final-velocity [vIFT]), sprint distance (absolute: ≥25.2km·h⁻¹, relative: ≥80% maximal sprint speed), and dynamic stress load. Internal load metrics were dRPE training loads. **Results:** Other than relative sprint distance, overall weekly external training loads were substantially greater for U18 and U23s when compared with U16s (effect size range: 1.09–1.99 [moderate to large]; ±90% confidence limits ~0.45). When compared with U16s, overall internal loads were substantially greater for U18s (0.69–0.95 [moderate]; ±~0.40), but not U23s. Differences in weekly training loads between U18s and U23s were inconclusive. **Conclusions:** Substantial differences in training loads between elite U16 players and their older counterparts, indicates the need for planned increases in training loads in anticipation of the transition into full-time training.

**Key words:** Team-sports; RPE; LTAD; Individualised training; Training load
**Introduction**

In soccer, a training programme which stresses all of the bodies physiological systems is used to promote adaptations with a view to enhancing physical performance (Bangsbo et al. 2006). To ensure that an appropriate stimulus is imposed, monitoring of player training load is essential and can facilitate effective training prescription, resulting in enhanced adaptations and reduced risks of non-functional overreaching (Malone et al. 2017; Scott et al. 2013). Specifically, the volume and intensity contributing to external loads (i.e. physical work completed), dictates the resultant internal loading (i.e. physiological stress), which drives adaptations (Impellizzeri et al. 2018). The quantification of external and internal loads, therefore, might facilitate effective planning and periodization.

Long-term athlete development (LTAD) models aim to promote gradual improvements in an athlete’s physical capabilities through systematic and controlled progressions in training load (Ford et al. 2011). While training history and experience are important in athlete development models, a key consideration for youth athletes (i.e., those aged 12-18 years) is maturation status, which is associated with periods of increased injury risk (Myer et al. 2011). Maturation status is often assessed in reference to the adolescent growth spurt, also known as ‘Peak Height Velocity (PHV)” (Towlson et al. 2020). Prescribed loads are particularly important in the transition between age-groups, to ensure that an appropriate stimulus is imposed to elicit performance improvements, whilst reducing the risk of non-functional overreaching (Wrigley et al. 2012). The transition between part-time and full-time training represents the period where load related injury risk is highest, and in English Professional Soccer this occurs between the under-16 and under-18 age-groups (Read et al. 2018). During this phase, an increase in weekly coaching hours from ~8 to 16 hours is stipulated by the Elite Player Performance Plan (EPPP) guidelines, which many English academies adhere to. Incidentally, an increased injury burden (i.e., Mean absence per injury per 1000 hours of football exposure) has been observed since the EPPP was introduced, with a 125 and 47% increase in injury burden in Under-16 and Under-18 groups, respectively, highlighting these key phases (Tears et al. 2018).

Despite increases in soccer training load research, literature investigating the training loads of young players competing in different age-groups is limited (Coutinho et al. 2015; Wrigley et al. 2012). Furthermore, exploration of the overall training loads of young players (i.e., matches, field-, and resistance-training) using an integrated monitoring approach suitable for disparate training modes, is lacking. This is highly relevant given the potential ‘spike’ in training load around transitional phases, and associated increases in injury risk (Tears et al. 2018).

External loads are commonly quantified using global navigation satellite systems (GNSS) and accelerometer derived measures (Akenhead et al. 2016). Total distance (m), high-speed running distance and sprint distance are commonly used metrics for assessing the demands of training and competition (McLaren et al. 2018). Traditionally, the locomotor thresholds used to define high-speed running and sprinting are set at >19.8 km·hr\(^{-1}\) and >25.2 km·hr\(^{-1}\), respectively, by wearable technology companies which is in line with thresholds set by PROZONE (Gregson et al. 2010). However, the individualization of these zones according to physiological constructs has become increasingly popular in soccer. Various lab (i.e., ventilatory thresholds or maximal aerobic speed [Hunter et al. 2015]), and field-based procedures (i.e., VAM-EVAL [Scott and Lovell, 2018]; Yo-Yo intermittent recovery test level 1 and maximal-sprints [Scott and Lovell, 2018; Hunter et al. 2015; Mendez-Villanueva et al. 2013]) have been used for this purpose. Given the logistical difficulties of testing team-sport
players in the lab, the use of field-based measures represents a practical approach to individualization, and the use of maximal and submaximal constructs combined i.e., maximal sprinting speed and estimated percentage of maximal aerobic speed (MAS) might represent best practice (Abbott et al. 2018; Fitzpatrick et al. 2018; Hunter et al. 2015).

The process of individualizing locomotor thresholds is underpinned by the belief that aligning thresholds with physiological constructs provides greater insight into training/match demands and the dose-response of soccer players with differing physical capacities (Abbott et al. 2018; Fitzpatrick et al. 2018). While Scott and Lovell (2018) reported that individualising locomotor thresholds was not beneficial in dose-response determination in elite female players (i.e. the interaction between external and internal load), individualising locomotor threshold was reported to be effective in determining dose-response in young male soccer players (Fitzpatrick et al. 2018).

This suggests that the process of individualizing according to physiological constructs might be particularly useful for practitioners working with young players. Accelerometer derived measures, such as dynamic stress loads (DSL) have also become integral to player monitoring. These measures provide an indication of mechanical stress (i.e., a combination of linear accelerations) (Beato et al. 2019; Vanrenterghem et al. 2017) and may be useful in fatigue management and subsequently injury prevention (Fitzpatrick et al. 2019). Internal loads are often quantified using heart-rate indices, but the use of differential ratings of perceived exertion (dRPE) are now commonplace, and provide greater detail with respect to ‘global’ training programmes (McLaren et al. 2017).

Specifically, dRPE might provide information on the cardiovascular and neuromuscular stress load–adaptation pathways (Vanrenterghem et al. 2017).

Given the importance of understanding training load progression in academy soccer, we aimed to provide a detailed quantification and comparison of the internal and external training loads completed by players in the U16, U18 and U23 age-groups of an EPPP Category 1 Academy during a 5-week training mesocycle. This included exploration of arbitrary and individualized locomotor zone classifications, mechanical stress and dRPE.

**Materials and Methods**

**Experimental approach to the problem**

We used a retrospective observational design to compare internal and external training loads. Data were collected from a 5-week meso-cycle during the competitive season (September–October 2018). The U18 and U23 players were full-time, the U16 players were part-time. Field-training and matches were completed on natural turf soccer pitches. Resistance training was completed in the gymnasium at the club’s training facility.

**Participants**

Forty players were recruited from under-16 (U16, n = 13: age = 15.3 ± 0.5 yrs, body mass = 66.1 ± 5.1 kg, stature = 177 ± 3.8 cm, 1.6 ± 0.6 yrs from PHV), under-18 (U18, n = 15: 16.8 ± 0.6 yrs, 69.7 ± 6.1 kg, stature = 178.4 ± 6.4 cm, 2.8 ± 0.5 yrs from PHV) and under-23 (U23, n = 12: 18.9 ± 1.0 yrs, 75.8 ± 4.8 kg, stature = 180.6 ± 3.4 cm) age-groups of an English Premier League academy. Only outfield players were included, given the dissimilar practices undertaken by goalkeepers. Ethical approval was obtained from the institutional ethics committee prior to commencement. This study was conducted in accordance with the declaration of Helsinki.
Procedures

External load data were collected for field-training and matches using an athlete tracking device (Statsports APEX, Statsports, Newry, Northern Ireland) with integrated GNSS (10 Hz) and a triaxial accelerometer (600 Hz). The validity of the GNSS has been explored with small errors (1–2%) reported for total distance and peak velocity in comparison to a criterion (Beato et al. 2018). For within-unit reliability, small typical errors (<2%) have been reported for total distance, maximal velocity and high-speed running variables (≥19.8 km·h⁻¹) (Thornton et al. 2019). Data were downloaded and inspected after each session/match using Statsports APEX software, with raw data extracted and stored in a customised database. Players wore the same tracking device throughout, within a custom-made vest. The athlete tracking devices were connected with 23 ± 1 satellites, while the horizontal dilution of precision was 0.4 ± 0.1.

Time-motion analysis data included total distance (TD; m), absolute high-speed running distance (HSRD, ≥19.8 km·h⁻¹, m); and sprint running distance (SpD ≥25.2 km·h⁻¹, m). Individualized HSRD and SpD were used to account for differences in physiological capacities of the players (Abbott et al. 2018; Dugdale et al. 2018). Our relative threshold for HSRD was 87% of a player’s final velocity on the 30–15 Intermittent Fitness Test (vIFT) (which corresponds approximately with maximal aerobic speed) in the week prior to the observation period (Buchheit and Laursen, 2013). Our relative SpD was set according to 80% of maximal sprinting speed (MSS) recorded during a 30-m sprint (Hunter et al. 2015). To assess the ‘mechanical stress’ accumulated, DSL was quantified (See Beato et al. 2019 for further detail on the algorithm). DSL has been demonstrated to have good reliability (CV <3%), and is reported to be effective in fatigue detection due to movement modification during intermittent exercise (Beato et al. 2019).

Approximately 15-minutes following matches and training sessions, players recorded dRPE for session breathlessness (sRPE-B) and leg muscle exertion (sRPE-L) (Weston et al. 2015). Ratings were provided in confidence using the CR100® scale, which was numerically blinded, labelled with the idiomatic English verbal anchors, and hosted on a bespoke, 7” touch-screen tablet application (LM700, Hong Kong, China: LeaningTech Industrial.) (McLaren et al. 2017). Training loads for breathlessness (sRPE-B-TL) and leg muscle exertion (sRPE-L-TL) were calculated by multiplying each dRPE by session duration in minutes (Weston et al. 2015). Prior to the observation period, players were given instruction on the definition of effort perception—including its separation from other exercise related sensations such as fatigue, pain and discomfort—and how to use the CR100® scale (Pageaux, 2016). Subsequently, RPE data were collected for two-weeks of training and fitness testing, allowing for familiarisation of the CR100® scale (i.e. anchoring) (Pageaux, 2016). Players wore a heart rate monitor (Polar Heart rate monitor, Polar T31 coded, Polar, Kempele, Finland) for field-training and matches. However, visual inspection of individual heart rate traces indicated ~30% of sessions with clear irregularities. The volume of missing data meant that meaningful insight derived from appropriate statistical analysis was not possible given the nature of this study. Therefore, we decided not to display heart rate data here.

From the initial sample (n = 40), we removed those suffering from musculoskeletal injury or those who did not complete the weekly training schedule (n = 5 players). To provide a true reflection of the average weekly training load, we then removed players who completed less than four out of the five weeks in full (n = 4 players). Our final dataset included 31 players with 898 training and match observations (U16, n = 10 players and 251 observations; U18, n =12 players and 378 observations; U23 n = 9 players and 269 observations).
Statistical analysis

Visual inspection of raw data via histograms and Q–Q plots for each age group by training typology identified several instances where measures were positively skewed. Descriptive statistics were therefore presented as median with quartiles. Analysis was performed on the natural log-transformed data, which was normally distributed. We used separate 2-level linear mixed effect models (SPSS version 24, IBM, Armonk, NY, US) to compare differences in weekly training loads between U16, U18 and U23 players. Training group was specified as a fixed effect (without intercept) and a random intercept for player ID (variance components covariance matrix) was included, accounting for the repeated within-athlete observations. The models estimated marginal means were back-transformed and all effects were expressed in standardized units (effect sizes). This was given as the mean difference divided by the overall (residual + intercept) standard deviation, pooled from both groups in each comparison. Effect sizes of 0.2, 0.6 and 1.2 were considered small, moderate and large, respectively (Buchheit, 2016; Hopkins, 2007).

Uncertainty in all differences and ranges of values compatible with our data and statistical models were expressed as 90% confidence limits (CL) (Greenland, 2019). We also applied minimum effects tests (MET; Murphy & Myors 1999) to provide a practically meaningful and probabilistic interpretation of the between-group differences in training loads. Minimum effects tests combine the strength of drawing inferences from the data in relation to meaningful effect sizes with a formal statistical foundation grounded in frequentist approaches to statistical inferences (Lakens et al., 2018; Aisbett et al. 2020). We converted the t statistic for the effect in relation to the threshold for a small effect size (difference – 0.2/ standard error of the difference) to a continuous probability via the one-tailed t-distribution. Minimum effects test p-values (pMET) were interpreted in terms of compatibility with a meaningful difference, using a conventional alpha value. When effects clearly overlapped both directions, or when pMET compatibility was ambiguous to weak in favour of the direction, the between group difference was deemed inconclusive (Lakens et al., 2018; Aisbett et al. 2020).

Results

The mean (± SD) 30-15 final-velocity (vIFT) (km·h⁻¹) of U16, U18 and U23 players were 19.7 (± 0.7), 20.6 (± 0.7) and 20.8 (± 1.1), respectively. Thresholds for relative HSRD (87% of vIFT; km·h⁻¹) were therefore 17.2, 17.9, and 18.1 respectively. Mean (± SD) maximal sprint speeds (MSS) (km·h⁻¹) of U16, U18 and U23 were 30.4, (± 1.4), 33.1, (± 0.8) and 34.2, (± 1.3). Thresholds for relative SpD (80% MSS; km·h⁻¹) were therefore 24.3, 26.5 and 27.3, respectively.

The median (range) number of training sessions and matches per week were 5 (3–9), 7 (3–11) and 6 (3–12) for U16s, U18s and U23s, respectively. Distributions of weekly external and internal training loads for each age-group throughout the observation period are displayed in Figure 1. The overall average weekly loads and volumes are shown in Table 1. Average weekly loads and volumes, and age groups comparisons for match-play, field and resistance training are shown in Tables 2 and 3, respectively. Differences in overall weekly volume and load between U16, U18 and U23 players are displayed in Figures 2 (A-C). With the exception of relative SpD, weekly volume and external loads of U18s and U23s were greater than U16s. Most of these differences were compatible with meaningful effects (pMET ≤ 0.006) and ranged between moderate to large (U18s; Figure 2A) and small to large (U23s; Figure 2B). The U18s internal loads were greater than the U16s by a similar compatibility (pMET ≤
When comparing U18s with U16s (Table 2), we observed higher weekly match TD ($p_{MET} = 0.030$; small to moderate), absolute HSRD ($p_{MET} = 0.012$; small to large), absolute SpD ($p_{MET} = 0.028$; small to moderate) and DSL ($p_{MET} = 0.016$; small to large). Only match relative SpD was greater in U23s when compared to U16s ($p_{MET} = 0.003$; moderate to large; Table 2). For field and resistance sessions (Table 3), weekly training volumes were greater for U23s ($p_{MET} \leq 0.001$; moderate to large) and U18s ($p_{MET} \leq 0.002$; small to large) when compared with U16s. Only weekly resistance training volume was greater in U23s when compared to U18s ($p_{MET} \leq 0.001$; moderate to large; Table 3). All field and resistance training loads were greater for U23s ($p_{MET} \leq 0.025$; moderate to large) and U18s ($p_{MET} \leq 0.002$; small to large) when compared with U16s, with the exception of relative SpD in U18s vs U16s ($p_{MET} = 0.59$; Table 3). When compared with U18s, U23s had a greater weekly field SpD (absolute: $p_{MET} = 0.008$; small to large, relative: $p_{MET} = 0.035$; small to moderate; Table 3) and resistance sRPE-L-TL ($p_{MET} = 0.025$; small to moderate; Table 3).

**Discussion**

Understanding training load within a young athlete’s long-term development is critical to the training process. Here, we compared the weekly external and internal loads undertaken by under-16, under-18 and under-23 players within an English Premier League Category 1 academy. Our results demonstrate moderate to large differences in arbitrary locomotor, relative locomotor, mechanical and perceptual loads, with U18 and U23 players undertaking greater training loads and training volumes in field and resistance training sessions than U16 players. While these findings seem intuitive, our investigation is the first to provide empirical evidence using an integrated monitoring approach. The observation of ambiguous, weakly compatible or inconclusive between-group differences in ‘relative’ sprint distance was also a key finding, highlighting the need for further work exploring individualised locomotor thresholds for very-high speed running. While U18 players completed more absolute and relative high-speed running in field-training than U23 players, all other between group differences in field training and matches were unclear.

Although our study is the first to provide a holistic (i.e., accumulated training loads for all modalities completed) perspective of training loads undertaken by young elite soccer players, the field-based external training loads of young players has been explored previously. Our findings somewhat support those of Coutinho et al. (2015) who explored the typical weekly loading of players competing in under-15, under-17 and under-19 age-groups. Upon reporting higher training loads in older players, the authors suggested that greater emphasis on tactical and technical development in younger age-groups might explain the lower training loads observed (Coutinho et al. 2015). Furthermore, our findings also support those of Abbott et al. (2018), with respect to the variability in external loads as a consequence of differing physical capacities of players. The weekly external loads we observed in U18 and U23 players were similar to that reported by Fitzpatrick et al. (2018) with comparable total distances (~29 km) and relative high-speed running distances (~2600 m > MAS). This suggests that the between club physical demands of elite young players within EPPP academies are likely homogenous, broadening the scope of our findings.
We observed moderate to large differences in relative high-speed running distances between the U16 and the U18/U23 groups. The use of combined arbitrary and individualised thresholds in the assessment of locomotion has been suggested to be an effective means of monitoring high-intensity activities in soccer (Fitzpatrick et al. 2018; Mendez-Villanueva et al. 2013). This might be of increasing importance when working with young players with differing physiological capacities that are largely dependent on training age, and perhaps maturational status and our findings present a platform for further work. For example, while all U16 players included in our study were > 1-yr post PHV (suggesting that they have progressed through the period of greatest risk due to maturation status), they exhibited lower physical capacities than older players providing further indication that individualised thresholds may be appropriate at this age. An unanticipated finding was the similarity in match loads between the U16 and U23 players despite the large differences in overall training loads. Furthermore, we also observed a higher relative-sprint distances in the U16 players during match-play. This is likely due to contextual factors, including tactical awareness and playing style of the older players, perhaps allowing more efficient outputs.

The quantification of the internal training load of all training through the use of dRPE was a novel component of our study. Only Wrigley et al. (2012) have attempted to quantify all training completed by young players previously, reporting differences in session RPE that were similar to our observations i.e., older players undertaking higher training loads. Here, we used dRPE and were able to provide further insight into the ‘central’ and ‘peripheral’ stimulus imposed on players. Our data indicate that peripheral and central exertion were higher in the U18 and U23 players than in the U16 players in field and resistance training, with moderate effects reported. These differences were of similar magnitude to that observed in the external training load measures. Match dRPE loads showed less consistent effects between groups, likely due to smaller discrepancies in duration, however. The use of dRPE in combination with external load measures presents a means of appraising the dose–response (i.e., how perceived training loads influence training adaptations) of young players by providing insight into the fitness-fatigue relationship (McLaren et al. 2020).

Another novel component of our study was the quantification of dynamic stress load (DSL) within a training meso-cycle of young soccer players. While a relationship between DSL and locomotor variables is likely, accelerometer derived measures provide further indication of mechanical stress (Beato et al. 2019). The substantial differences in DSL between U16 and U18 players provide further evidence for the use of a long-term progression model towards these transitional phases. It should be noted that match accumulated DSL contributed almost 50% of weekly total DSL, and it has been reported that mechanical stress can be influenced by playing position, which should be considered when contextualising DSL data (Barron et al. 2014). The use of DSL might also present insight into dose-response of players, through the ability of this measure to detect fatigue through mechanical movement adaptation (Beato et al. 2019). Moreover, reductions in mechanical load for a given external output may be an indicator of favourable adaptation (Vanreunterghem et al. 2020). It should be noted that further validation work in soccer players is needed to allow practitioners to have more confidence in DSL.

We observed high week-to-week variability in the external and internal training loads undertaken, as evidenced through the distribution of data presented in Figure 1. While there were insufficient data to provide accurate statistical estimates of this variability, reconciling our observations with the findings of previous work suggests that within- and between-player variability across a soccer training programme is inherently large (Fitzpatrick et al. 2018; Wrigley et al. 2012). Some of this variability likely reflects planned fluctuation (i.e., periodization), but
individual deviation from the systematic changes in training load is also evident. This presents challenges in the planning and periodization of training and indicates that close inspection of an individual’s training data is needed to ensure appropriate and consistent loading occurs.

Our study is the first to provide empirical data comparing the overall training loads of part-time (U16) and full-time (U18/U23) players, and while our data is not longitudinal, it suggests that substantial increases are likely to occur over age-group transitions. Differences in weekly external loads including total distances (~10 km), high-speed running (~800 m), sprint distance (~200 m), relative high-speed running distance (800 m), DSL (~700 AU) in U18 players in comparison to U16 players is a clear indicator of the greater demands placed on the neuromuscular system. This is further supported through the increased perceived peripheral loads we observed in field and resistance training (sRPE-L-TL) and might provide an explanation for increased injury burden in U18 English academy players (Tears et al. 2018), given the association between sudden increases in training load, non-functional overreaching and reductions in neuromuscular capacity (Williams et al. 2017).

Recent evidence suggests that time above MAS has a positive relationship with aerobic fitness in young players (Fitzpatrick et al. 2018). Our results, therefore, suggest that the older players training stimulus (~700-m more above MAS) elicits greater potential for aerobic development. The positive relationship between external load and fitness development in soccer has also been described with respect to high-intensity performance, with very high and high-speed running distances covered by players being correlated with sprint and jump performance (Owen et al. 2019). These concepts must be considered with respect to overtraining theory, however, whereby more is not always better. It is suggested that players with greater strength capacities are less likely to incur load related injuries, with lower-limb asymmetries in particular identified as a risk factor (Lehance et al. 2011). Our reported differences in resistance training load, therefore, are key findings. Given the evidence around the effectiveness of resistance training and the suggestion that participating in sports training alone is not enough to minimize injury risk (Myer et al. 2011), the implementation of a well-planned and progressive resistance training programme with young players might mitigate injury risk during age-group transitions between the U16 and U18 groups.

Our study provides insight into the training loads undertaken by elite young soccer players, but is not without limitation. We acknowledge that our data represents a single training mesocycle and that loading varies across the season. However, the mesocycle chosen is perhaps the most stable of the soccer season i.e., immediately following the pre-season transition, and is the period where the least movement of players between consecutive age-group squads occurs (which is commonplace in academy soccer). Nonetheless, exploring seasonal loading represents opportunity for future investigations. We also acknowledge that the data collected represents the training practices of one club, but, the academy from which data were collected is an English Premier League Category 1 Academy, and adheres to EPPP guidelines, which ensures homogeneity amongst the practices carried out by similar academies.

In conclusion, we observed substantial differences in weekly match, field and resistance training loads between U16 players and those in older age-groups (U18 and U23) in a professional soccer academy. This has important implications and the substantial increases in field and resistance loads between U16 and U18 players, suggest that well-planned interventions should be put in place to facilitate this transition. A periodized/progressive programme
including a well-structured resistance training component to enhance neuromuscular capacities and a progressive, controlled increase in field-based training loads should be implemented prior to transitioning to full-time training. We found no evidence for meaningful difference or equivalence between the loads of U18 and U23 players, and a potential differentiator of these playing levels could be tactical and technical qualities. Finally, the use of individualised locomotor thresholds might represent a practical and effective approach to monitoring young players, but the use of individualised sprint thresholds requires further exploration.

Disclosure of Interest

The authors report no conflicts of interest.
References


### TABLE 1: Average weekly training volume and load completed by U16, U18 and U23 players throughout the five-week observation mesocycle.

<table>
<thead>
<tr>
<th>Measure</th>
<th>U16s</th>
<th>U18s</th>
<th>U23s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (hh:mm)</td>
<td>04:50</td>
<td>06:31</td>
<td>07:01</td>
</tr>
<tr>
<td>TD (m)</td>
<td>19445</td>
<td>30641</td>
<td>28547</td>
</tr>
<tr>
<td>Absolute HSRD (m)</td>
<td>733</td>
<td>1719</td>
<td>1541</td>
</tr>
<tr>
<td>Relative HSRD (m)</td>
<td>1618</td>
<td>2663</td>
<td>2328</td>
</tr>
<tr>
<td>Absolute SpD (m)</td>
<td>70</td>
<td>258</td>
<td>306</td>
</tr>
<tr>
<td>Relative SpD (m)</td>
<td>129</td>
<td>120</td>
<td>122</td>
</tr>
<tr>
<td>DSL (au)</td>
<td>684</td>
<td>1345</td>
<td>1198</td>
</tr>
<tr>
<td>sRPE-B-TL (au)</td>
<td>12184</td>
<td>15977</td>
<td>14506</td>
</tr>
<tr>
<td>sRPE-L-TL (au)</td>
<td>12081</td>
<td>17300</td>
<td>15370</td>
</tr>
</tbody>
</table>

*Geometric estimated marginal means

44. **TABLE 2**: Average weekly match volume and load with comparisons between U16, U18 and U23 players throughout the five-week observation mesocycle.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Average weekly match volume and load*</th>
<th>U18s vs U16s</th>
<th>U23s vs U16s</th>
<th>U23s vs U18s</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>U16s</td>
<td>U18s</td>
<td>U23s</td>
<td>ES (90% CI)</td>
</tr>
<tr>
<td>Duration (hh:mm)</td>
<td>01:26</td>
<td>01:25</td>
<td>01:19</td>
<td>-0.03 (-0.44 to 0.39)</td>
</tr>
<tr>
<td>TD (m)</td>
<td>8726</td>
<td>11640</td>
<td>10225</td>
<td><strong>0.71 (0.27 to 1.15)</strong></td>
</tr>
<tr>
<td>Absolute HSRD (m)</td>
<td>418</td>
<td>687</td>
<td>562</td>
<td><strong>0.81 (0.38 to 1.24)</strong></td>
</tr>
<tr>
<td>Relative HSRD (m)</td>
<td>885</td>
<td>1095</td>
<td>941</td>
<td>0.38 (-0.02 to 0.78)</td>
</tr>
<tr>
<td>Absolute SpD (m)</td>
<td>45</td>
<td>99</td>
<td>83</td>
<td><strong>0.73 (0.28 to 1.18)</strong></td>
</tr>
<tr>
<td>Relative SpD (m)</td>
<td>81</td>
<td>43</td>
<td>26</td>
<td>-0.68 (-1.19 to -0.18)</td>
</tr>
<tr>
<td>DSL (au)</td>
<td>297</td>
<td>529</td>
<td>449</td>
<td><strong>1.00 (0.40 to 1.60)</strong></td>
</tr>
<tr>
<td>sRPE-B-TL (au)</td>
<td>5123</td>
<td>4458</td>
<td>4477</td>
<td>-0.17 (-0.50 to 0.17)</td>
</tr>
<tr>
<td>sRPE-L-TL (au)</td>
<td>5027</td>
<td>4795</td>
<td>4747</td>
<td>-0.07 (-0.40 to 0.27)</td>
</tr>
</tbody>
</table>

*Geometric estimated marginal means
Asterix symbols indicate compatibility with a meaningful difference: * = p_{MET} < 0.05; ** = p_{MET} < 0.005.
### TABLE 3: Average weekly field- and resistance-training volume and load with comparisons between U16, U18 and U23 players throughout the five-week observation mesocycle.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Average weekly training volume and load*</th>
<th>U18s vs U16s</th>
<th>U23s vs U16s</th>
<th>U23s vs U18s</th>
</tr>
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<tbody>
<tr>
<td><strong>Field Training</strong></td>
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<tr>
<td>Duration (hh:mm)</td>
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<td>04:18</td>
<td>05:12</td>
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<tr>
<td>TD (m)</td>
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<td>17938</td>
<td>21432</td>
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<tr>
<td>Absolute HSRD (m)</td>
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<td>815</td>
<td>1130</td>
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<td>Relative HSRD (m)</td>
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<tr>
<td>Absolute SpD (m)</td>
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<td>Relative SpD (m)</td>
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<tr>
<td>DSL (au)</td>
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<td>sRPE-B-TL (au)</td>
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<td>9074</td>
<td>9630</td>
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<td>sRPE-L-TL (au)</td>
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<td>9909</td>
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<td><strong>Resistance Training</strong></td>
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<td>01:28</td>
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<tr>
<td>sRPE-B-TL (au)</td>
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<td>1466</td>
<td>1719</td>
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<td>sRPE-L-TL (au)</td>
<td>1079</td>
<td>2017</td>
<td>3065</td>
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</tbody>
</table>

*Geometric estimated marginal means
Asterix symbols indicate compatibility with a meaningful difference: * = $p_{\text{MET}} < 0.05$; ** = $p_{\text{MET}} < 0.005$.

**List of Figures**

**FIGURE 1:** Distribution of average weekly loads completed by U16 (white), U18 (light grey) and U23 (dark grey) players throughout the five-week observation mesocycle. Data are displayed as the median (horizontal box line), interquartile range (IQR; box) and non-outlier range (± IQR × 1.5; whiskers). Outliers (> or < ± IQR × 1.5) are displayed as individual data-points. Mean lines, joined between weeks, are also shown.

**FIGURE 2:** Forest plot comparison of average weekly loads between the (A) U16 and U18, (B) U18 and U23 and (C) U16 and U23 players throughout the five-week observation mesocycle

[Footnote]

Error bars are 90% confidence intervals.

Asterix symbols indicate compatibility with a meaningful difference: * = $p_{MET} < 0.05$; ** = $p_{MET} < 0.005$.

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