Title:
Organized chaos in late specialization team sports: Weekly training loads of elite adolescent rugby union players

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Abstract

Phibbs, PJ, Jones, B, Roe, G, Read, DB, Darrall-Jones, J, Weakley, J, Rock, A, and Till, K. Organized chaos in late specialization team sports: weekly training loads of elite adolescent rugby union players. J Strength Cond Res 32(5): 1316–1323, 2018—The aim of this study was to quantify the mean weekly training load (TL) of elite adolescent rugby union players participating in multiple teams and examine the differences between playing positions. Twenty elite male adolescent rugby union players (17.4 6 0.7 years) were recruited from a regional academy and categorized by playing position: forwards (n = 10) and backs (n = 10). Global positioning system and accelerometer microtechnology was used to quantify external TL, and session rating of perceived exertion (sRPE) was used to quantify internal TL during all sessions throughout a 10-week in-season period. A total of 97 complete observations (5 6 3 weeks per participant) were analyzed, and differences between positions were assessed using Cohen's d effect sizes (ES) and magnitude-based inferences. Mean weekly sRPE was 1,217 6 364 arbitrary units (AU) (between-subject coefficient of variation [CV] = 30%), with a total distance (TD) of 11,629 6 3,445 m (CV = 30%), and PlayerLoad (PL) of 1,124 6 330 AU (CV = 29%). Within-subject CV ranged between 5 and 78% for sRPE, 24 and 82% for TD, and 19 and 84% for PL. Mean TD (13,063 6 3,933 vs. 10,195 6 2,242 m) and PL (1,246 6 345 vs. 1,002 6 279 AU) were both likely greater for backs compared with forwards (moderate ES); however, differences in sRPE were unclear (small ES). Although mean internal TLs and volumes were low, external TLs were higher than previously reported during preseason and in-season periods in senior professional players. Additionally, the large between-subject and within-subject variation in weekly TL suggests that players participate in a chaotic training system.

Introduction

The monitoring of training load has become increasingly popular with coaches and support staff because of its relationships with performance, injury, and illness (22). The quantification and management of training loads can be challenging, especially in late specialization team sport athletes (30). This is because of the complexity of playing and training programs (i.e., concurrent participation within multiple teams supervised by multiple coaches) (23,29). When athletes train with multiple teams at various training locations simultaneously, it is unlikely that practitioners can be present at every session to monitor training loads of their respective athletes. Recently, there has been a call for a coordinated and systematic approach for training load monitoring in adolescent athletes via the use of objective quantification tools such as global positioning systems (GPS) (2). The addition of a subjective global measure of training load (e.g., session rating of perceived exertion [sRPE]) may also offer further insight into the internal training loads of these athletes because a single measure (e.g., GPS only) may not adequately rep- resent the complete demands of training (40). The use of sRPE can be used to provide a measure of global training load, as it can be used across all modes of training unlike GPS measures, which are limited to field-based training (10). The quantification of the external (i.e., stimulus applied to the athlete: distance covered, or weight lifted) and internal (i.e., individual response to the stimulus: heart rate or rating of perceived exertion [RPE]) training loads would provide a more comprehensive insight into the over- all demands of training (3,22).

In England, participation in rugby union is the highest in the world (17), although little is known about the training loads of adolescent rugby union players. In English rugby union, players participate with numerous teams (i.e., school, club, representative) supervised by multiple coaches concurrently because players are not contracted to a single organization until they finish school (e.g., after 18 years of age). Monitoring and understanding workloads of adolescent rugby union players are important to provide an evidence base, whereby training and match exposures can be manipulated to maximize positive training outcomes (e.g., athletic and skill development) and minimize negative effects (e.g., illness, injury, nonfunctional overreaching, and overtraining) (7,21,24). In the absence of evidence evaluating the load players are exposed to, it would be difficult for practitioners and coaches to make informed the decisions on whether players are participating in excessive or insufficient training.

Training volumes in English youth rugby union players has been shown to be higher in academy players (190 hours per season) compared with schoolboy players (72 hours per season), although no data were reported for mean weekly values (28). Sub-elite English adolescent rugby union players have been found to have median (interquartile range) weekly sRPE loads of 1,014 (1,016) arbitrary units (AU) (39), although values in players competing at a higher playing standard (e.g., academy) or at multiple playing standards are yet to be determined. A range of weekly training and match play volumes of between 370 and 515 minutes have been reported in Australian adolescent rugby union players, depending on playing standard (23). However, the quantification of these values was obtained using self-reported weekly training diaries: a method that has recently been demonstrated to have a poor typical error of the estimate for recall of training duration (i.e., minutes; 30%) and intensity (i.e., RPE; 26%) (30). Although there are no objective data available on the accumulated weekly workloads in adolescent rugby union, during a typical field-based training session, under-18 players have been shown to cover distances of 2,925–4,176 m measured using GPS, with sRPE loads of 168–236 AU, depending on the playing standard (29). Despite information available on mean field-based session loads (29), the typical load accumulated within a week (including rugby-specific, strength and conditioning, and other organized and recreational activity loads) would provide a better indication of the overall training load in adolescent rugby union players.

Rugby union has 2 distinct positional groups, categorized based on their roles within a match: forwards and backs (15,33,34). To date, there are no data available on the differences in weekly training loads between forward and back playing positions in adolescent players, which have been previously shown to differ in senior professional training (6). Understanding position-specific training loads can sup- port the practitioner in (potentially) modifying loads for specific groups of players. During the in-season, senior professional backs have been shown to cover greater total distances compared with forwards, although no significant differences in mean weekly sRPE loads were found (6). A previous study in Australian adolescent rugby union players found no significant differences in mean training session de- mands between forwards and backs (25). Although the authors acknowledged that because positional demands have been consistently observed in the senior game, a position- specific approach should be implemented in the adolescent game to adequately prepare players for the progression in the sport (25).

Because both insufficient and excessive workloads may negatively impact athletic development, injury risk, playing progression, and general well-being (1,21,24), a greater understanding of the accumulated training load within a training week would help coaches and practitioners to maximize athletic development and reduce the risk of negative training outcomes. Thus, the primary aim of this study was to quantify the mean weekly internal (i.e., sRPE) and external (i.e., GPS and accelerometer) training loads of elite adolescent rugby union players participating within multiple environments, and to quantify the variability of these loads. A secondary aim of this study was to compare the mean weekly training loads between playing positions.

Methods

Experimental Approach to the Problem

In the prospective cohort study design, each subject was monitored over a 10-week in-season period to quantify the mean weekly subjective and objective training loads, excluding match play. Training load is a modifiable risk factor for injury (12) because it can be directly influenced by coaches, and thus, only training loads were analyzed in this study. Match play loads in adolescent rugby union players are well established (14,33,34) but are not easily influenced by coaches (with the exception of selection and playing time), and therefore were excluded from the analyses. Because weeks with multiple matches may reduce the overall training volume and frequency, only single-match weeks with no missing data were included for analyses in this study. Training practices were not interfered with by the researchers at any time. Data were collected midseason (October–December) to standardize observations for stage in the competitive season where players may be participating with school, club, and regional academy and representative squads concurrently. A total of 97 complete weekly observations (5 6 3 weeks per participant) were included in the final analyses.

Subjects

Twenty male elite adolescent rugby union players from a regional academy squad in England were recruited for this prospective study. Subjects also concurrently participated in training sessions and represented their respective independent schools and amateur clubs. Subjects were categorized into 2 groups depending on their respective playing position: for- wards (n = 10; age, 17.4 6 0.7 years; stature, 186.8 6 6.5 cm; body mass, 96.0 6 9.0 kg; maximal sprint velocity [Vmax], 8.2 6 0.4 $m\cdot s^{-1}$) and backs (n = 10; age, 17.3 6 0.7 years; stature, 180.7 6 5.5 cm; body mass, 83.1 6 9.9 kg; Vmax, 8.7 6 0.3 $m\cdot s^{-1}$). All subjects and parents provided written informed consent before participation, and ethics approval was granted by the institutional research ethics committee.

Procedures

To quantify external training loads, each subject was provided with a microtechnology unit (Optimeye S5; Catapult Innovations, Melbourne, Australia) equipped with GPS and triaxial accelerometer and a tight-fitting custom-made vest to allow the units to be placed on the upper back between the scapulae. All subjects wore the same microtechnology units throughout the data collection period. The validity and reliability of these units have been previously reported (4,38). The error of measurement (i.e., coefficient of variation [CV]) for 10 Hz GPS units have been reported as 8.3, 4.3, and 3.1% for velocities between 1–3, 3–5, and 5–8 $m\cdot s^{-1}$, respectively, with the between-unit reliability at the same velocities as 5.3, 3.5, and 2.0% (38). The accelerometers have also been shown to have an acceptable CV for within-unit (0.9–1.1%) and between-unit (1.0–1.1%) reliabilities (4). The mean 6 standard deviation (SD) of satellites connected was 14.6 6 0.7, and horizontal dilution of precision was 0.64 6 0.08 during data collection. Before any observations, each subject completed a familiarization session wearing the microtechnology unit and completed two 40-m sprints to measure Vmax. The Vmax value used in the final analysis was taken as the highest speed reached during either sprint effort in the familiarization trial or during any training session during the data collection period. To quantify locomotor loads, GPS metrics (total distance [TD], low-speed activity distance [LSA; m ,61% Vmax], high-speed running distance [HSR; m $61% Vmax], very high–speed running distance [VHSR; m $90% Vmax], and peak velocity [Vpeak]) (9) were re- corded for all rugby training sessions. Because backs are commonly reported as faster than forwards (13,18,35) and because of the potential large within and between positional group differences in Vmax, individualized thresholds for running demands were used in this study. Triaxial accelerometer measures (PlayerLoad [PL], and PLslow [PL ,2 $m\cdot s^{-1}$]), representing accumulated accelerations in the anteroposterior, mediolateral, and vertical planes, were recorded to quantify global and low-velocity physical loads because these metrics have been related to collision-based activity in rugby union (37). At the end of each week, all recorded microtechnology data were downloaded to the manufacturer's software (Sprint 5.1.4; Catapult Innovations). Once downloaded, all data were cropped so that only training time (including warm-up and cooldown), as recorded by the daily training load questionnaires, was included.

To quantify internal training loads, sRPE was calculated from a self-reported online daily training load questionnaire for all training activities, recently shown to be valid (typical error of the estimate = 4.3%) (30). Frequency, intensity, time, and type of all training activities were recorded with a self-reported daily training load questionnaire (30). Rating of perceived exertion was selected from a drop-down menu corresponding with the text descriptors from a modified Borg's category ratio-10 scale (16). Training time was recorded to the nearest minute of duration, which was subsequently multiplied by the corresponding RPE weighting to provide sRPE values. Activity types were categorized as rugby training (e.g., rugby field training, individual and team skills training, and captain's runs), gym training (e.g., resistance training, prehabilitation, and rehabilitation sessions), and other training or activity (e.g., field and gym-based conditioning, other organized sport or exercise, and recreational exercise or activities).

Statistical Analyses

Mean weekly training load were calculated from individual subject means from their respective weekly sessions to control for multiple and uneven observations (41).
Descriptive statistics were used to present the mean, SD, minimum, maximum, range, and CV of the overall group data. All data were log-transformed before effect size and magnitude-based inference (MBI) analyses to reduce bias associated with nonuniformity error. To assess the magnitude of between-position differences, Cohen's d effect sizes (ES) were calculated with threshold values set at ,0.2 (trivial), 0.2–0.6 (small), 0.6–1.2 (moderate), 1.2–2.0 (large), and $2.0 (very large) (26). To assess for practical significance, MBI analysis was used with the threshold for a change to be considered practically important (the smallest practical difference; SPD) set at 0.2 3 between-subject SD, based on Cohen's d ES principle (26). The probability that the magnitude of difference was greater than the SPD was rated as 25–75%, possibly; 75–95%, likely; 95–99.5%, very likely; .99.5%, almost certainly (26). Where the 90% confidence interval (CI) crossed both the upper and lower boundaries of the SPD (ES 6 0.2), the magnitude of difference was described as unclear (26).

Results

Table 1 presents the mean 6 SD, minimum, maximum, and between-subject CV of weekly training volumes and internal and external loads of adolescent rugby union players. Table 2 presents the individual range and within-subject CV of weekly training load measures. Figure 1 presents the mean 6 SD and between-group differences (Cohen's d ES, 90% CI, MBI) in mean weekly internal and external training loads between forwards and backs. Figure 2 presents the mean 6 SD and between-group differences in mean weekly locomotor loads between forwards and backs.

There were unclear differences between forwards and backs for mean weekly PLslow (504 6 160 vs. 580 6 169 AU, respectively), training volume (301 6 107 vs. 301 6 80 minutes, respectively; ES = 0.0; 90% CI, 20.6 to 0.6), and sRPE (1,186 6 380 vs. 1,249 6 365 AU, respectively). Backs had likely greater TD (13,063 6 3,933 vs. 10,195 6 2,242 m), LSA (12,142 6 3,672 vs. 9,694 6 2,215 m), VHSR (34651vs.568m), and PL (1,2466345vs.1,0026279 AU) compared with forwards. Backs also had very likely greater HSR (807 6 387 vs. 482 6 174 m) and almost certainly greater Vpeak (8.0 6 0.3 vs. 7.1 6 0.4 $m \cdot s^{-1}$; ES = 1.7; 90% CI, 1.1 to 2.3) compared with forwards.

Discussion

This is the first study to quantify the mean weekly internal and external training loads of elite adolescent rugby union players training across multiple playing environments (i.e., school, amateur club, and regional academy). Overall, mean weekly training volumes and internal loads were low; however, large between-subject and within-subject variation was observed, suggesting that workloads should be monitored and managed on an individual basis. Backs had substantially greater mean running (i.e., TD, LSA, HSR, and VHSR) and physical loads (i.e., PL) compared with forwards, although the difference between the groups for internal training loads and volumes were unclear. These findings demonstrate that the external training loads differ substantially between forward and back positional groups, which may have implications for the overall development of players as a result of the positional differences observed during match play.

Weekly training volumes in this study (301 6 92 minutes) were lower than previously reported in elite Australian adolescent rugby players (421 6 211 minutes, including match play) (23) and senior professional players (414 6 210 minutes) (8) but greater than that observed in sub-elite English adolescent players (188 6 144 minutes) (39). Overall sRPE loads in this study (1,217 6 364 AU) were lower than previously reported in senior professional players (1,522 6 203 and 1,581 6 317 AU, for early and late in-season, respectively) (12) but greater than subelite English adolescent players (median [interquartile range] = 1,014 [1–016] AU) (39). Interestingly, mean weekly in-season running loads were greater in this study (11,629 6 3,445 m) compared with values previously reported in senior professional players during the in-season (professional forwards and backs = 7,827 6 954 and 9,572 6 1,233 m, respectively) (6) and preseason (professional forwards and backs = 9,774 6 1,404 and 11,585 6 1,810 m, respectively) (5) phases of competition, despite lower total training time. Although it is beyond the scope of this study to determine the appropriateness of these specific running loads, exposure to higher weekly running loads than those observed during the preseason in senior professional players would appear excessive and may be an example of unnecessary workload exposure in players participating with multiple teams. The effect of these high in-season running loads on subsequent match play performance and injury risk should be investigated in future research.

The between-subject (Table 1) and within-subject (Table 2) variability of these data would suggest that there is a lack of a "typical" weekly training structure for the majority of these players. Large between-subject variability of training loads has been previously reported in a cohort of sub-elite English rugby union players (range, 195–4,888 AU), suggesting that weekly training loads may differ substantially between players (39). Additionally, the large within-subject variability appears beyond what would be advocated within a well- organized training program (19,20). For example, the subject "forward 2" had a weekly TD ranging from 6,382 to 26,253 m (CV = 75%), PL ranging from 682 to 2,773 AU (CV = 75%), and sRPE ranging from 300 to 1,725 AU (CV = 78%). The accumulation of high weekly running distances within the training week (e.g., 26,253 m), which are more than 6 times the TD covered by under-18 schools forwards during match play (4,232 6 985 m) (34), may be placing the player at a substantial risk of injury, if the player is not adequately prepared for those high loads. As recent studies have suggested, it is not simply high weekly (i.e., acute) training loads that are related to injury risk but rather rapid spikes or dips in acute loads in relation to chronic loads (e.g., accumulated over the previous 28 days), known as the acute: chronic workload ratio (19,20). Therefore, the large within-subject variability of weekly training loads in these players is of concern. Because of methodological and logistical issues (e.g., participant recording failure and equipment malfunction), it was not possible to collect continuous weekly observations, which could have been used to calculate acute:chronic workload ratios or exponentially weighted moving averages (19,43). Future research should aim to assess the week-to-week changes in acute internal and external loads of adolescent rugby union players relative to chronic loads (42).

There were unclear differences between forwards and backs for mean weekly internal training loads and volumes (as well as for rugby, gym, and other training modes), which may need to be investigated further with a larger sample size. However, the substantial differences in mean weekly external training loads (excluding PLslow) reflect their position- specific activity patterns observed during match play (14,33,34). Backs covered substantially greater TDs

(13,063 6 3,933 vs. 10,195 6 2,242 m), LSA (12,142 6 3,672 vs. 9,694 6 2,215 m), HSR (807 6 387 vs. 482 6 174 m), and VHSR (34 6 51 vs. 5 6 8 m) compared with forwards. Direct comparisons cannot be made to previous literature regarding the distribution of running loads into LSA, HSR, and VHSR because of the use of individualized thresholds; however, this approach is the strength of the current study. Previous research in senior professional players found that backs completed greater distances at arbitrary thresholds of high-speed (5.6–7.5 m/s) and very high–speed (.7.5 m/s) bands compared with forwards (5,6). Because backs generally have a greater Vmax than forwards (13), it may be expected that backs would cover greater distances above arbitrary thresholds, as the corresponding running intensities would be relatively easier compared with their slower teammates. In the current study, backs had a higher Vmax compared with forwards and reached almost certainly greater absolute Vpeak (8.0 6 0.3 vs. 7.1 6 0.4 m/s) during their training week. Thus, individualized velocity thresholds may be more appropriate for training monitoring purposes because it allows analysis of movement demands specific to a player's own capacity rather than an arbitrary group boundary (35). Of note, both groups were exposed to limited distances at VHSR, with 6 subjects not reaching the threshold at any time during this observational period. Although speed development may be a greater priority in the preseason, regular exposures to VHSR should also be planned during the in-season to reduce the risk of injury associated with this type of activity when underprepared (27).

The use of accelerometer metrics, such as PL and PLslow, have been previously related to collision-based activity in adolescent rugby union players (37), although values of mean weekly PL values for training are currently unavailable in the adolescent or senior game. Backs had likely greater total weekly PL than forwards (1,246 6 345 vs. 1,002 6 279 AU), which may be expected because of its previously re- ported nearly perfect relationship with TD (37) and because backs frequently engage in more high-velocity accelerations and sprint efforts (6,31). Differences in PLslow between for- wards and backs (504 6 160 vs. 580 6 169 AU) were unclear, a metric that has previously been shown to have a strong relationship with collision activity in rugby match play (37). This may be a result of the lack of full-contact collisions in training compared with matches (36). Although PLslow may offer a proxy measure of collision frequency, the quantification of additional static exertion activities frequently performed by forwards remains challenging (e.g., pushing in scrums and mauls, lifting in lineouts, and work at the ruck) (32) and may explain some of the disparity between external and internal training loads in the forwards group. However, individual characteristics will also influence the internal response to the training stimulus and consequently affect external:internal load ratios.

It is important to note that the current study excludes matches and includes training data only. Match play loads will further add to the weekly workloads of these players, and the inclusion of multiple games within a training week may lead to further within-subject variability of workloads. Longitudinal research is required, including match play loads, to fully understand the week-to-week variation in total weekly workloads. Because these players participate with multiple teams concurrently, a consensus between support staff must be agreed upon as to who is responsible for monitoring workloads in these players. Coaching and support staff from regional academies, amateur clubs, and schools need to communicate and work together for a coordinated and systematic approach of monitoring adolescent rugby union players to be effective. The use of sRPE may allow simple and accurate remote training load quantification for athletes training in multiple venues, which may be advantageous when expensive technology (e.g., GPS) may not be available (10). Objective measures, such as heart rate, blood lactate concentration, and GPS measures, have been highly correlated to sRPE (11,16). Further- more, remote collection of sRPE has recently been validated using a self-reported online questionnaire 24 hours after exercise in an adolescent athlete population (30). Thus, sRPE is an available tool for researchers and practitioners to monitor the global training load of youth athletes training and competing in a complex system. However, if used in isolation, the limitations of this measure should be considered because 2 similar sRPE values may be attributed to very different external loads. For a comprehensive analysis of training load, a combination of internal and external load measures should ideally be used.

In conclusion, mean weekly internal training loads of elite English adolescent rugby union players were greater than previously reported in sub-elite adolescent players but lower than senior professional players, despite the mean weekly running loads being higher in this study compared with preseason and in-season values in senior professionals. The large between-subject and within-subject variability in weekly training loads suggest that there is a lack of regular training load, highlighting the need for appropriate management of workloads of these players, despite them all being within the same elite program (i.e., regional academy). The range of values observed suggests that during some weeks, these players are exposed to inadequate or excessive training loads. There were substantial differences between forwards and backs for mean weekly external training loads, with backs having greater weekly TD, LSA, HSR, VHSR, and PL, supporting the use of a position-specific training approach in elite adolescent rugby union players. Future longitudinal research is required to investigate the week-to-week variation and acute:chronic training loads in adolescent rugby union players because they may have implications for both athletic development and injury prevention.

Practical applications

Coaches working with athletes participating in late specialization sports should be aware of the high mean weekly running loads, which are likely accumulated from an exposure to various teams. Within adolescent rugby union training, when a player's time is shared between environments, coaches should prioritize the needs of the player, given his or her exposure to other programs. Within this study, it seems that the running volume was greater than expected. Given that the weekly training loads were highly variable, likely because of the participation with multiple teams, practitioners working with this cohort should work together to manage the overall load that the player is exposed to, reducing the risk of spikes in training load, which are associated with injury. Training loads (including rugby- specific and strength and conditioning loads) should be planned and periodized to avoid such high variability. As such, respective coaches and support staff should coordinate to agree on appropriate training and match load exposures based on individual-specific monitoring data to maximize positive training outcomes and minimize potential negative effects.

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