Player responses to match and training demands during an intensified fixture schedule in professional rugby league: A case study.

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Abstract

Player loads and fatigue responses were reported in 15 professional rugby league players (24.3 ± 3.8 y) during a period of intensified fixtures. Repeated measures of internal and external loads, perceived wellbeing and jump flight time were recorded across 22 days, comprising nine training sessions and matches on days 5, 12, 15 and 21 (player exposure: 3.6 ± 0.6 matches). Mean training load (session RPE x duration) between matches was 1177, 1083, 103, and 650 AU, respectively. Relative distance in Match 1 (82 m/min) and Match 4 (79 m/min) was *very likely* lower in Match 2 (76 m/min) and *likely* higher in Match 3 (86 m/min). High intensity running (≥5.5 m/s) was *likely* to *very likely* lower to Match 1 (5 m/min) in Matches 2-4 (2, 4 and 3 m/min, respectively). Low intensity activity was *likely* to *very likely* lower from Match 1 (78 m/min) in Match 2 (74 m/min) and Match 4 (73 m/min), but *likely* higher in Match 3 (81 m/min). Accumulated accelerometer load for Matches 1-4 was 384, 473, 373 and 391 AU, respectively. Perceived wellbeing returned to baseline values (~21 AU) before all matches but was *very* to *most likely* lower the day after each match (~17 AU). Pre match jump flight times were *likely* to *most likely* lower across the period, with mean values of 0.66, 0.65, 0.62 and 0.64 s before Matches 1-4, respectively. Across a 22-day cycle with fixture congestion, professional rugby league players experience cumulative neuromuscular fatigue and impaired match running performance.

Introduction

Rugby league is an intermittent contact team sport, comprising periods of high-intensity activity (e.g., high-speed running, sprinting, and physical collisions) and low-intensity recovery (e.g., standing, walking, and jogging) performed over two 40-minute halves.[1,2] These activities are known to lead to immediate and prolonged fatigue in elite players,[3,4] observed as losses in muscle function and increases in perceived soreness and fatigue that remain for up to four days after a match.[3,4,5] Players therefore require appropriate between-match recovery to minimize the negative effects of fatigue on performance.

Over an eight-month rugby league season players typically compete with 5–10 days between matches.[5] Fixtures are interspersed with multi-component training sessions (i.e. resistance, conditioning and skills) where training loads are manipulated depending on the number of days between matches.[5] There are, however, intensified periods of competition when players are required to compete with relatively short between-match recovery periods. Studies have examined fatigue and performance responses of sub-elite[6] and junior players[7] during tournaments where multiple matches were played over five days. In both studies the accumulation of fatigue as the tournament progressed impacted on players' capacity for high intensity exercise. However, the use of sub-elite players and non-standard match formats that included 2 x 20 min halves and multiple matches in one day fails to replicate the demands imposed on elite players. In elite players, shorter recovery times between matches (5-6 days) have resulted in increases[8,9] and decreases[10] in relative distance covered during matches compared to longer turnarounds (>9 days). While several contextual factors explain the running intensity of match play,[9,10] increases in relative low intensity activity[8] and reduced high-intensity running[10] are associated with fatigue. The causes of fatigue in this situation are likely to be multifactorial, including muscle tissue damage, an altered sense of effort, reduced muscle glycogen re-synthesis and dehydration.[11] As yet, studies examining match running performance of elite rugby league players during congested fixture periods have done so without simultaneous assessments of player fatigue status.

Findings are equivocal with respect to the effect of congested fixture periods on physical performance in other team sports.[12,13] In elite European rugby league, congested fixture periods are limited to a one month period scheduled around a public holiday (i.e. Easter) that involves all teams playing three matches with between match recovery periods of two and five days. Until now, the training, match demands and fatigue responses of elite rugby league players during this period of intensified competition remain unknown. Such information would enable a better understanding of how elite rugby league players are managed and respond to a novel congested fixture period. Accordingly, this study sought to examine professional rugby league players from one elite club during a novel congested fixture period to understand the training and match loads and any cumulative fatigue responses.

Methods

Participants and design

With institutional ethics approval, 15 elite male players (8 forwards, 3 adjustables and 4 outside backs) from the same professional club (mean age: 24.3 ± 3.8 y, stature: 1.85 ± 0.10 m, body mass: 102.7 ± 11.7 kg) provided informed consent to participate in the study. All measurements were completed during a 22-day period (Days 1 to 22) where the team played in four competitive Super League fixtures on Days 5, 12, 15 and 21 (one home and three away fixtures). During the period, all players were involved in nine training sessions and at least three matches from four during the fixture period (mean 3.6 ± 0.6). The mean score deficit was 5 ± 3 points, with the team losing three matches (Matches 1-3; score: 24-22, 12-4 and 20-28, respectively) and winning one (Match 4; score: 8-11). Matches 1, 2, and 4 were played as away fixtures, with players covering an estimated mean return travel distance by coach of 190 ± 174 km. All matches were played in dry conditions, with the mean temperature and relative humidity during matches being 7 ± 1°C and 86 ± 12%, respectively.

Training load was measured during training sessions and matches using micro-technology devices and session rating of perceived exertion (sRPE) multiplied by session duration. Perceived wellbeing was measured throughout the 22-day period using a five-point psychometric questionnaire while muscle function was measured the day before and after each match using a countermovement jump. These measurements were taken in the morning on arrival at the training ground (~9-10 am) and before any exercise or recovery was performed. All players performed a 60-minute compulsory recovery session the day after each match, comprising compression and 2 x 5 min bouts of seated cold water immersion at 12˚C. A schematic of the 22-day schedule, including training matches and when measurements were taken is provided in Figure 1.

****Figure 1 about here****

Measurement of external and internal load

Players wore a micro-technology device (Viper pod 2, STATSports, Belfast, UK) between the scapulae in a tight-fitting vest (training) or a custom designed pocket in the back of their playing shirt (matches). The GPS device sampled at a rate of 10 Hz, with the player wearing the same GPS unit for all training sessions and matches.[14] All devices were activated outdoors 30 minutes before data collection to enable acquisition of satellite signals. After each training session and match, GPS data were downloaded using the manufacturer's software package (Viper PSA software, STATSports, Belfast, UK) and truncated based on the time players were active on the training pitch or field of play. This device has been used previously to quantify movement demands of team sport athletes during training and competition,[15] while in-house measures of validity and reliability were acceptable (coefficient of variation <5%). Movement data included: total distance (m), relative distance (m/min) and relative distances in low intensity activity (<5.4 m/s) and high-intensity running (≥5.5 m/s). In addition, accumulated accelerometer load was derived from the micro-technology device's embedded tri-axial accelerometer and presented as an arbitrary value (AU) based on the combined rate of change of acceleration in three planes of movement: forward, lateral and vertical. GPS and accelerometer metrics were based on those used presently by the club and consistent with those used in collision-based team sports.[16, 17]

Quantification of training and match loads was also assessed using the session rating of perceived exertion (sRPE).[18] Using a 10-point scale, players reported their sRPE ~20 minutes after a field, resistance-based training session or match from which load (AU) was calculated by multiplying sRPE by total training or match time. To further understand the integration of internal and external loads, the ratios of sRPE to relative distance (internal: external load ratio)[19] were also calculated.

Psychometric questionnaire

Based on similar methods used previously in rugby,[3,5] players provided ratings of perceived fatigue, mood, upper body muscle soreness, lower body muscle soreness, sleep quality and stress using a 1-5 Likert scale. Higher values were indicative of a positive response to the question, with lower values representing a negative outcome. All players were accustomed to this procedure as part of their routine monitoring and were asked to complete this on their own to avoid any influence from other players or coaching staff.

Countermovement jump

The jump began with the participant in an upright position after which they were required to flex the knees rapidly to approximately 90º before jumping for maximal height with hands remaining on hips throughout. Flight time calculated as the difference between landing and take-off time, was recorded using a timing mat system (Just Jump System, Probotics Inc., US). Participants performed three jumps with the longest flight time taken for analysis. All players were accustomed to the jump procedures as part of their regular monitoring process. The coefficient of variation for this measurement with the same group of players is 1.8%.

Statistical analysis

Data were log transformed to reduce bias due to non-uniformity of error and analysed using the effect size (ES) statistic with 90% confidence intervals (CI) and % change to determine the magnitude of effects. Thresholds for the magnitude of the observed change for each variable was determined as the within-participant standard deviation (SD) in that variable x 0.2, 0.6 and 1.2 for a small, moderate and large effect, respectively. Threshold probabilities for a meaningful effect based on the 90% CI were:

<0.5% most unlikely, 0.5–5% very unlikely, 5–25% unlikely, 25–75% possibly, 75–95% likely, 95–99.5% very likely, >99.5% most likely.[20] Effects with 90% CI across a likely small positive or negative change were classified as unclear. All calculations were completed using a predesigned spreadsheet.[21]

Results

Training and match times

Values are reported as mean ± SD. Total training time and match time over the 22 days was 706 ± 96 min and 246 ± 78 min, respectively. Compared to before Match 1 (137 ± 43 min) there were reductions in training time between Matches 1-2 (102 ± 30 min; 24.1%, ES -0.56 ± 0.44, *likely*), 2-3 (38 ± 22 min; -73.7%, ES -2.72 ± 1.17, *most likely*) and 3-4 (87 ± 14 min; -37.6%, ES -0.96 ± 0.20, *very likely*). Compared to Match 1 (59.0 ± 22.9 min), players match times were longer for Match 2 (71.6 ± 22.1; 37.8%, ES 0.77 ± 0.40, *very likely*), Match 3 (68.3 ± 23.0; 16.3%, ES 0.36 ± 0.42, *possibly*) and Match 4 (73.1 ± 27.4; 33%, ES 0.69 ± 0.47, *very likely*).

Training loads

Compared to before Match 1 (1177 ± 241 AU), internal training loads (Figure 3) were lower between Match 1 and 2 (1083 ± 207 AU; -8.1%, ES -0.35 ± 0.47, *possibly*) between Match 2 and 3 (103 ± 31 AU; -91.7%, ES -10.25 ± 0.85, *most likely*) and Match 3 and 4 (650 ± 80 AU; -43.9%, ES -2.38 ± 0.41, *most likely*). Accumulated accelerometer load before Match 1 (Days 1-4: 164 ± 94 AU) was similar to values between Match 1 and 2 (150 ± 30 AU; 9.8%, ES 0.16 ± 0.55, *unclear*), but lower between Match 2 and 3 (22 ± 10 AU; -83.4%, ES -2.32 ± 0.57, *most likely*) and Match 3 and 4 (122 ± 63 AU; -24.3%, ES -0.29 ± 0.25, *possibly*). The mean distance covered during training sessions was 57 ± 12 m/min, comprising 2.8 ± 1.6 and 56 ± 7 m/min of high-intensity running and low-intensity activity, respectively. Data for daily movement characteristics and training loads are shown in Figure 2.

Match loads

Total distance covered in Match 1 (4758 ± 1842 m) was lower than Match 2 (5451 ± 1886 m; 24.2%, ES 0.55 ± 0.43, *likely*), Match 3 (5836 ± 2046 m; 23.4%, ES 0.54 ± 0.39, *likely*) and Match 4 (5885 ± 2099 m; 28.0%, ES 0.63 ± 0.44, *likely*). Relative total distance over the four matches (Figure 2) from Match 1 (82 ± 10 m/min) was lower in Match 2 (76 ± 8 m/min; -9.9%, ES 0.77 ± 0.33, *very likely*), higher in Match 3 (86 ± 7 m/min; 6.1%, ES 0.44 ± 0.39, *likely*) and the same in Match 4 (79 ± 9 m/min; -3.8%, ES -0.28 ± 0.64, *unclear*).

Relative high-intensity running (Figure 2) in Match 1 (5 ± 1 m/min) was followed by lower distances covered in Match 2 (2 ± 1 m/min; -63%, ES -3.69 ± 1.30, *most likely*), lower in Match 3 (4 ± 2 m/min; -17.2%, ES -0.70 ± 0.88, *likely*) and in Match 4 (3 ± 1 m/min; -27.1%, ES -1.17 ± 0.94, *very likely lower*). Additionally, relative low intensity activity (Figure 2) decreased from Match 1 (78 ± 8 m/min) in Match 2 (74 ± 7 m/min; -7.5%, ES -0.65 ± 0.32, *very likely*), followed by an increase in Match 3 (81 ± 6 m/min; 5.7%, ES 0.46 ± 0.36, *likely*) and decrease in Match 4 (73.3 ± 4.5 m/min; -5.6%, ES -0.48 ± 0.37, *likely*). Accumulated accelerometer load increased from Match 1 (384 ± 200 AU) to Match 2 (473 ± 188 AU; 30.6%, 0.51 ± 0.31, *likely*), was similar in Match 3 (373 ± 163 AU; -3.0%, -0.05 ± 0.27, *unclear*) and higher in Match 4 (391 ± 168 AU; 7.4%, 0.11 ± 0.25, *possible*). Match load (Figure 3) increased from Match 1 (502 ± 216 AU) to Match 2 (696 ± 167 AU; 53.5%, ES 0.9 ± 0.41, *very likely*), Match 3 (624 ± 232

AU; 22.8%, ES 0.43 ± 0.46, *possibly*) and Match 4 (560 ± 197 AU; 13.1%, ES 0.26 ± 0.37, *possibly*). When match load was expressed as a ratio to relative speed (internal: external load; Figure 3), there was a higher internal: external load than Match 1 (6.4 ± 3.2 AU) at Match 2 (9.3 ± 2.1; 70.3%, ES 0.99 ± 0.39, *most likely*), Match 3 (7.3 ± 2.7 AU; 15.7%, ES 0.27 ± 0.47, *possibly*) and Match 4 (7.2 ± 2.7 AU; 17.6%, ES 0.30 ± 0.42, *possibly*).

*******Insert Figure 2 here*******

******* Insert Figure 3 here*******

Perceptual and neuromuscular fatigue responses

Compared to Day 1 (20.4 ± 1.5 AU), Day 2 (20.6 ± 0.8 AU; 2.4%, ES 0.32 ± 0.42) and Day 4 (21.0 ± 2.0 AU; 2%, ES 0.27 ± 0.44), perceived wellbeing was lower after Match 1 (Day 6: 17.1 ± 4.2 AU; -19.3%, ES -2.87 ± 1.17, *most likely*). Wellbeing then returned to baseline before Match 2 (Day 11: 20.8 ± 2.4) but was again lower at Day 13 (17.3 ± 3.0; -18.5%, ES -2.73 ± 1.01, *most likely*). Similarly, wellbeing returned to baseline before Match 3 (Day 14: 20.4 ± 1.4 AU) but was then lower at Day 16 (18.8 ± 2.7; -10.7%, ES -1.52 ± 0.93, *very likely*) and Day 17 (16.5 ± 3.7; -22%, ES -3.33 ± 1.49, *most likely*). Before Match 4 (Day 20) wellbeing was higher than baseline (20.9 ± 1.2 AU; 3.5%, ES 0.46 ± 0.54, *likely*) and then lower at Day 22 (16.9 ± 2.9 AU; -20.2%, ES -3.02 ± 0.86, *most likely*). Responses were *unclear* on the remaining five occasions. Data are shown in Figure 4.

Compared to before Match 1 (Day 4: 0.66 ± 0.04 s), pre-match flight times were lower for Match 2 (Day 11: 0.65 ± 0.04 s; -2.3%, ES -0.37 ± 0.26, *likely*), Match 3 (Day 14: 0.62 ± 0.04, -6.9%, ES -1.16 ± 0.37, *most likely*) and Match 4 (Day 20: 0.64 ± 0.04 s; -2.9%, ES -0.47 ± 0.37, *likely*). Post-match flight times were also lower for Match 1 (Day 6: 0.63 ± 0.04 s; -5.3%, ES -0.65 ± 0.32, *very likely*), Match 2 (Day 13: 0.59 ± 0.05 s; -8.2%, ES -0.76 ± 0.41, *very likely*), Match 3 (Day 16: 0.61 ± 0.04 s; -2.6%, ES -0.30 ± 0.22, *likely*) and Match 4 (Day 22: 0.60 ± 0.04 s; -3.6%, -0.44 ± 0.43, *likely*) when compared to pre-match values.

*****Insert Figure 4 here*****

Discussion

For the first time, we describe the training and match loads of elite rugby league players during a 22-day mesocyle comprising a congested fixture period of four matches with between-match periods of six, two and five days, respectively. While there were progressive reductions in jump flight time across the 22 days, large reductions occurred after Match 2 that remained into Match 3. Running performance fluctuated between the four matches, but reductions in high intensity running and increases in low speed activity in later matches were indicative of an overall slowing of movement speed. Taken together these data suggest that across a 22-day mesocycle with fixture congestion, professional players experience neuromuscular fatigue and impaired physical match performance despite an obvious reduction in training load between fixtures.

In the present study, internal training loads in the period before Match 1 and between

Match 1 and Match 2 were consistent with those reported previously for elite rugby league teams during between-match periods of similar length.[5] While internal training loads reflected the combination of multi-component training modalities, external loads (m/min) reflected lower movement speeds that were indicative of training that focused on skills rather than physical conditioning.[2] Large reductions in between-match training loads then followed for the period of congested fixtures between Match 2 and 3 and Match 3 and 4. These observations reaffirm that coaches adopt a more conservative approach with training and emphasize recovery when the between-match time is reduced.[5]

Given the large variability associated with high intensity running in rugby league,[22] match load (session RPE x playing time) and accumulated accelerometer load provide relatively stable measures to compare between matches.[23] While match loads reported in Match 1 and Match 4 were similar and consistent with those reported by Waldron and colleagues,[1] values reported for Match 2 and Match 3 were much higher. An increase in playing time accounts for some of the increase in load for Match 2, although this occurred despite a reduction in total relative running intensity that comprised reductions in both relative low intensity activity and high intensity running and a higher Internal: External ratio. This is explained by the ~31% increase in accumulated accelerometer load for Match 2, which suggests that players experienced an increase in collision-orientated activity during this match.[17] Indeed, the addition of collisions is known to reduce relative total distance during intermittent running activity.[24] In Match 3 the high match load was accompanied by greater relative total distance, explained primarily by an increase in relative low intensity activity and decrease in relative high intensity running. These alterations in movement characteristics are consistent with short between match recoveries in team sport players[8,10], and suggest a change in movement characteristics towards slower movement velocities that is accompanied by a reduction in muscle function as observed through reduced jump flight times.

Large reductions in countermovement flight time the day after each match are consistent with data reported previously on elite rugby league players.[3,4] There was also a non-linear decline in countermovement jump performance across the 22-day cycle that was indicative of an accumulated neuromuscular fatigue. While flight time was shorter than before Match 1 at all time points, the most notable reduction occurred around Match 2 and Match 3. This reaffirms the increased demands observed in Match 2 and indicates players' lower limb muscle function was not fully recovered before Match 3. A reduction in muscle function has been used to explain players adopting more slow-intensity activity,[25] and would likely have contributed to the observed changes in movement characteristics in Match 3. We propose that only two days between matches is not sufficient to enable professional rugby players to recover before another match. Practitioners and coaches should also be mindful of cumulative fatigue that might reduce the muscle tissues' threshold for tolerance to stress, beyond which a player's risk of injury is increased.[26] Indeed, fatigued compared to non-fatigued muscle is less capable of absorbing energy that means it could be more susceptible to injury.[27]

Changes in perceived wellbeing in the days after a match were consentient with those reported already for elite rugby league players.[3] However, despite the progressive decline in muscle function across the 22-day period, wellbeing always returned to baseline before each match. This finding reaffirms the poor association between subjective and objective measures of fatigue in athletes.[28] Although changes in wellbeing in the day after a match support the sensitivity of psychometric questionnaires to acute increases in training and playing load,[28,29] we question the utility of this measure in situations where players are expected to perform during periods of congested fixtures. That is to say, when players are faced with unusually short between match recoveries subjective responses are influenced by the proximity of the next match that increases the player's willingness to provide more favorable answers. This seems to be a limitation of subjective questionnaires when used with rugby players and reaffirms the addition of objective measures when trying to interpret a player's fatigue status.[11]

This study is not without limitations, many of which are related to collecting data from professional athletes in their normal working environment. Like studies in other team sports, [30] we present a case that reflects the training and match characteristics of only one professional club. A study using multiple clubs would provide a larger number of players and data that reflects the competition more broadly; however, a study of this kind would be difficult given the reluctance of professional clubs to share such data. How each opponent performed is also likely have influenced the results observed in this study. Again, access to the opponent's data was not possible and cannot be accounted for in our interpretations. We use no biochemical measurements to accompany muscle function and subjective assessments of wellbeing. While measures such as creatine kinase,[3,6] glutamine:glutamate[29] and sIgA[31] might provide a mechanistic insight to players fatigue, the lack of control associated with a real-world environment and reluctance of players made such measurements difficult to employ. Given the novelty of the data, we are confident that our study provides important insight into a congested fixture period in professional rugby league players that has not been reported before.

Practical applications

During periods of congested fixtures with as little as only two days between elite rugby league matches, coaches should carefully manage a player's time on the field of play to ensure running intensity and performance is maintained in matches played. Using carefully planned interchange strategies or resting players from some fixtures during the congested period should be considered, with objective markers of muscle function used to inform such decisions. Administrators and those responsible for setting of fixture scheduling might also consider these data and the appropriateness of short between match recoveries for optimal player performance, wellbeing and match quality.

Conclusions

During a congested period of fixtures including two games in four days, we have observed that coaches reduce training loads with an emphasis towards match performance. Despite this and the inclusion of recovery strategies after matches, players experience a gradual decrease in neuromuscular function across an intensified competitive period. This is accompanied by changes in running performance, whereby an increase in running distance is achieved by longer playing times and more slow intensity activity. Finally, two days recovery between matches is insufficient for professional rugby league players given neuromuscular function is not recovered, which results in more slow intensity activity in the second match.

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Figure Legends

Figure 1. Schematic showing training and match schedule of the 22-day competitive period. Load = measures of external (GPS) and internal (sRPE) load; WB = measures of player well-being measured; CMJ measures of countermovement jump; CR coach rating (1-5). Grey shading indicates match.

Figure 2. Mean ± SD daily relative total distance (m/min) covered as relative low-intensity activity (black bars) and relative high-intensity running (white bars) for training and matches. Grey shading indicates match. The magnitude of the effect size is indicated for Total, Low and High intensity running. * denotes large change compared to Match 1. # denotes moderate change compared to Match 1. † denotes small change compared to Match 1.

Figure 3. Mean ± SD Training/Match load (black bars) and Internal to External ratio (white circles) during the 22-day cycle (Day 1-22). Grey shading indicates match. The magnitude of the effect size is indicated for Training/Match Load. * denotes large change compared to before Day 1. # denotes moderate change compared to before Match 1. † denotes small change compared to before Day 1.

Figure 4. Mean ± SD countermovement jump flight time (black bars) and perceived wellbeing (white circles) during Days 1-22. * denotes large change compared to before Day 1. # denotes moderate change compared to before Day 1. † denotes small change compared to before Day 1.