Top secret training data? External training loads of a cup winning English Super League rugby league team

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Running Title: **Training load of rugby league players**

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ABSTRACT

This study quantified the field-based external training loads of professional rugby league players using global positioning systems technology across a playing season. Eleven professional rugby league players were monitored during all field-based training activities during the 2014 Super League season. Training sessions undertaken in preseason (*n* = 211 observations), early (*n* = 194 observations), middle (*n* = 171 observations) and late (*n* = 206 observations) phases of the in-season were averaged for each player and used in the analyses. Large reductions in external training loads between preseason and in-season periods were observed. Within season, a decrease in intensity (relative distance, absolute and relative total-HSR) with a limited change in training duration was observed. These data provide a useful reference for coaches working with similar cohorts, while future research should quantify the adequacy of the training loads reported, considering impact on performance and injury.

Key words: Training load, GPS, Periodisation

INTRODUCTION

Coaches and practitioners working with athletes determine the *load* or *exposure* (e.g., session duration and intensity) of training sessions. These *loads* are typically accumulated during technical or tactical training sessions, or the need to provide players with an appropriate physiological load to either simulate a positive fitness adaptation or facilitate recovery (1). Within rugby league, players require well developed physical qualities to compete at an elite level (2-4), given the game comprises high-intensity activities (e.g., sprinting, tackling) (5). However, to date there are limited training data available for rugby league coaches at any level to use as a reference for what may be an appropriate *load* (1).

The rugby league season is classified into three distinct periods; preseason, in-season and off-season (6). The objective of the preseason training period is to develop the physical characteristics of players that have been detrained during the off-season (7, 8). During this training period, players are physically overloaded to mediate a super-compensation response, subsequently enhancing physical performance (9). During the in-season period (when players are competing in weekly matches) the intention is to provide a training stimulus to maintain the fitness of players without inducing match-performance debilitating fatigue (10). Furthermore, the aim is to *peak* towards the end of the season, where teams compete in Cup and knock-out competitions (4).

Advances over the last decade in Global Positioning Systems (GPS) technology have permitted the quantification of the movement demands of player activity during training and match-play (11). Research in rugby league to date has predominantly focussed upon the movement demands of match-play (5, 12, 13), with limited studies investigating the 'load' of training (14). Studies exploring training load in rugby league are limited to pre-season training periods (14), utilise total session duration as a measure of external training load (15), or only quantify specific training activities (e.g., traditional conditioning, repeated high-intensity effort, game-based training, skills) (8). The demands of two separate 12-week pre-season training schedules (14) were also limited to high speed running (>15 $km \cdot hr^{-1}$), body load and total impacts as a measure of external training load for players, thus further research is needed to fully understand the movement demands of players not only during pre-season, but also throughout the different phases of the in-season (early, mid, late) period.

Given that rugby league players engage in a diverse range of training modes in order to induce specific adaptations needed to succeed in competition (8), understanding the specific training exposure during field based training throughout a season would allow coaches and practitioners to evaluate current practice. Therefore, the purpose of this study was to compare the differences in the external training load experienced by professional rugby league players who were part of a Cup winning team during field-based training sessions at different stages of the season (i.e., pre- vs. early, mid and late in-season) using GPS technology.

METHODS

Participants

Eleven male professional rugby league players (age, 26.5 ± 5.3 years; height, 183.9 ± 8.0 cm; body mass, 95.8 ± 10.5 kg) from a professional English Super League club participated in the study. The team were a Cup winning side during this respective season. The sample consisted of eleven players (four positional forwards and five positional backs, who were all regular starting players), as opposed to the full squad due to the availability of GPS units. Ethics approval was granted from Leeds Beckett University ethics committee and all players provided written consent to participate in the study.

Design of Study

A repeated measures design was employed to investigate the external training load throughout the 2014 European Super League season in professional rugby league players. External training load was quantified using GPS technology during all field-based training sessions (i.e., all training sessions that took place outdoors on a rugby pitch). The training sessions were completed as part of the club's normal training. Training phases were broken down into four eleven week training phases and classified as preseason (November 18th to February 6th; mean 3.5 ± 1.2 training sessions per week), early (February 10th to April 25th; mean 2.5 ± 0.7 sessions per week), middle (April 28th to July 3rd; mean 2.4 ± 0.7 sessions per week) and late (July 7th to September 17th; mean 2.8 ± 0.6 sessions per week) season. Data observations for each seasonal period were; preseason n = 211, early n = 194, middle n = 171 and late n = 206. To account for uneven data observations (i.e., due to injury, missed training, non-collection by the GPS unit), data were averaged for each player within each of the four seasonal phases. This allowed a repeated measures design to compare the differences specifically between the phases of the season. Mean individual data were used in the analysis and reported for each phase.

Procedures

All participants wore a GPS unit (STATSports Viper Pod, STATSports Technologies LTD) during training as part of their normal practice. Participants wore the same GPS unit, to account for inter-unit variability. The sampling rate of the GPS unit was 10 Hz (16). GPS units were worn in a purpose-designed fitted vest and positioned in the centre area of the upper back, superior to the scapula level with thoracic vertebrae 1. This was regular practice for players who had been wearing GPS technology for 3-4 years during training and match play. Units were switched on 30 minutes prior to the session to allow the satellite signal to be detected and switched off immediately after the session. Units were then downloaded to a laptop

(Dell, Latitude) using STATSports software (Viper) and the session was cut from the beginning to the end of the training session by the lead researcher. This was identified by recording the start time of training, then synchronising the timing using the STATSports software. Previous studies have reported the validity and reliability of GPS (STATSports) units (<5% coefficient of variation; CV), showing the units provide an accurate description of movement based variables in team sport athletes (17-19).

Session duration was calculated in time (minutes) from the beginning of the warm up until the end of the training session. Total distance (metres) was again taken from the beginning of warm up until the end of the training session. Distance was recorded in 6 velocity zones as used previously (20);

Walking (0.01 – 1.59 $m \cdot s^{-1}$),

Jogging (1.60 – 2.69 $m \cdot s^{-1}$),

Cruising (2.70 – 3.79 $m \cdot s^{-1}$),

Striding (3.80 – 4.99 $m \cdot s^{-1}$),

High-speed running (HSR; 5.00 – 5.49 $m \cdot s^{-1}$),

Sprinting (≥5.50 $m \cdot s^{-1}$)

HSR and sprinting were aggregated to represent total-HSR, which was also calculated relative to training duration (total-HSR$\cdot min^{-1}$). Relative distance ($m \cdot min^{-1}$) was calculated by dividing total distance by the session duration (minutes).

Statistical Analyses

Data are presented as mean ± standard deviations (SD) for the external training load. Preliminary analyses on data using Kolmogorov-Smirnov test was conducted to check for normality. A repeated measures analysis of variance (RM ANOVA) was used to examine the differences for each variable between phases of the season (i.e., preseason, early, mid and late phase of the in-season), with

Bonferroni corrections for multiple comparisons. Cohen's *d* effect size (ES) statistics (21) were also calculated. ES's were interpreted as <0.20 = *trivial*, 0.20-0.59 = *small*, 0.60-1.19 *moderate*, 1.20-2.00 = *large*, >2.00 = *very large*. SPSS (version 20.0; IBM, Armonk, NY, USA) was used to conduct analysis, with all statistical significance set at $P < 0.05$.

RESULTS

Table 1 shows the mean ± SD for external training session load for preseason, early, mid and the late phase of the in-season. A significant overall effect between phases of the season was observed for all variables, excluding variables relative to time (i.e., relative distance and relative total-HSR distance).

*** Insert Table 1 Here***

Effect size and *post-hoc* comparisons between the stages of the season (e.g., preseason vs. early) are shown in Table 2.

*** Insert Table 2 Here***

Very large differences were observed between preseason and in-season (i.e., early, mid and late phase) for session time and total distance. *Very large* differences were also observed for preseason vs. early and mid-phase of the season for jogging distance, and also between preseason and the late phase of the season for total-HSR.

Large differences were observed for preseason vs. early and mid-phase of the season for walking distance, preseason vs. late phase of the season for jogging distance and preseason vs. in-season (i.e., early, mid and late phase) for HSR. *Large* differences were also observed for sprinting distance between preseason and mid and late phase of the season, and total-HSR between preseason and early and mid-phase of the season.

Moderate differences were observed for walking (preseason vs. late), jogging (mid vs. late phase), cruising (pre vs. all in-season phases), striding (preseason vs. late) and sprinting (pre vs. early, early vs. late, mid vs. late) between phases of the season. *Moderate* differences were also observed for total-HSR and relative total-HSR distance between early vs. late, and mid vs. late. Relative total-HSR distance was also *moderately* different between pre and late phase of the season.

All other differences were either *trivial* or *small.*

DISCUSSION

The study showed that overall session training loads were higher in preseason compared to the in-season training period. This study also showed that the mean training session load was similar throughout the in-season phases, although a reduction in intensity, specifically absolute and relative total-HSR in the late in-season phase was observed. Previous studies have used GPS technology to describe the match demands (5, 12, 13) and observe short term training periods (i.e., preseason; (8, 14)) in rugby league. However, this is the first study to quantify and compare the external training load throughout the different phases (i.e., pre vs early, mid and late in-season) of the rugby league season using GPS metrics.

Data presented in this study can be used as a reference by coaches working in sports with long in-season periods, following preseason preparatory phases. During the in-season period, the aim of the coach is to prescribe training to develop or retain any fitness qualities developed during preseason, alongside the technical and tactical requirements of the sport. Training prescription and manipulation should be undertaken, while considering the fitness: fatigue models proposed (22) to ensure players can compete weekly. When evaluating the data presented in this study, training volume and training intensity should be differentiated to understand the specific stimulus provided (thus how players may respond) and how coaches may further manipulate their training sessions. Within this study, training volume variables can be attributed to both session duration and total distance, while overall intensity can be attributed to relative distance and also relative and absolute total-HSR.

The mean preseason session duration in this study is similar to previously reported by Weaving and colleagues during their observations of a rugby league preseason period (14). The overall intensity (e.g., relative distance) during preseason appears much lower than previously reported during English and Australian rugby league match play (95.8 ± 19.6 and 90.2 ± 8.3 $m \cdot min^{-1}$; (5)). In contrast to this, the relative total-HSR was greater during preseason than previously reported during English and Australian rugby match play (6.1 ± 1.8 and 7.8 ± 2.1 $m \cdot min^{-1}$; (5)). This suggests players are likely being conditioned for HSR match play activity during training, which has been previously attributed to match success (23). While it is not clear if this is the optimum training prescription for players during preseason due to the lack of physiological data presented, this study does provide the first insight into seasonal field-based training loads.

What is clear from this study is the apparent *very large* reduction in training time between the preseason and in-season training period. Similarly, Gabbett et al. (15) previously observed preseason-training loads were higher than in-season training periods, however only reported session duration and RPE as a measure of training load. While players are required to also compete in matches in addition to training during the in-season period, the training volume during a session (i.e., duration) should be modified to account for this. It is unclear at present how much volume (in addition to intensity) is required to maintain the fitness adaptations achieved during the preseason period. In addition to the reduction in session training volume between the preseason and in-season periods, a *large-very large* reduction in intensity (total-HSR) was observed, which was *small-moderate* when expressed relative to time (relative total-HSR). In contrast, relative distance was greater in-season than in preseason (*small* difference), which is in line with the *large-very large* reduction in walking and jogging between preseason and the in-season period. Although *moderate-large* reductions were also observed for HSR and sprint distance, relatively a lesser reduction between preseason and the in-season period was observed in comparison to lower speed activities. This may represent the coach's intention of maintaining session intensity, during the in-season period. Similarly to preseason, the relative total-HSR was greater and relative distance was lower during the in-season period than reported during English and Australian rugby match play (5). The appropriate management of training intensity and duration is especially pertinent given the length of the rugby league season (9 months). Rugby league players should be in peak physically condition at the end of the season, given this is where both the Cup and league knock-out competition takes place (4).

Overall there was a limited change in training load during the in-season training periods. It has been suggested that in accordance with traditional periodisation models, training load must be varied in order to elicit optimal physiological adaptations and limit the negative effects of fatigue (10). Daily variation may have taken place during training, which could have been lost when aggregating the data, thus future studies should investigate this. Twist et al. (5) found that during match play, relative distance covered, low, moderate and HSR activity did not differ across the early, mid and late in-season periods in both the English and Australian rugby league competition. As such, it appears players are able to maintain the physical outputs required during match play, throughout the season.

Observations of in-season training loads show a *small* increase between the early to mid and mid to late phases (based on time), thus coaches may be increasing the volume of training sessions towards the end of the season for either physical or technical and tactical reasons. Despite the observed *small-moderate* ES's as an absolute the change is by only ~1 minute, thus likely not important. Studies within soccer have shown the maintenance of training session volume (e.g., duration) from the early to the mid phase of the season (76 ± 24 and 76 ± 13 minutes) prior to a reduction at the end of the season (60 ± 20 minutes) (24). A progressive decrease in volume and increase in intensity would be indicative of a traditional periodisation strategy (25), although given these players are required to compete every week, the optimal annual manipulation of training load is still debated (26).

Despite the *small* increase in session duration from the mid to late phase of the season, it would appear from the external loads that training sessions decreased in intensity (e.g., reduction in HSR, sprinting, absolute and relative total-HSR). Although the aims of the coaching team were not quantified at any time during this study, it could be speculated that the decreased intensity was due to the focus on technical and tactical aspects, as opposed to the physical conditioning of players, where higher intensity training may have been observed. Furthermore, it may have been a subconscious effort from the players who were unable to run at a high intensity due to the presence of fatigue accumulated throughout the season. Within soccer, both volume (e.g., duration, distance) and intensity (e.g., relative distance and HSR) are reduced towards the end of the season (24), in an attempt to dissipate any accumulated fatigue (26).

What is apparent in this study is the main determinant of total, walking, and jogging distance is training duration, as similar trends were observed between the respective variables. As such, throughout the season, coaches should monitor session duration as a *proxy* measure of load during training, if GPS technology is not available.

The current notion surrounding training load (indicative of both volume and intensity), is that players should try and maintain high loads throughout the season (22, 26). The consequences of such are well developed physical qualities alongside preparedness for the competition demands (22). It appears that how coaches progressively manipulate training exposure to achieve high loads is more important than whether or not players are exposed to high or low training loads (26). The acute (i.e., one-week) to chronic (i.e., four-weeks) ratio of training exposure appears a predictor of injury risk (22) and injury appears to relate to team success (i.e., ranking) in rugby union (27), thus should be a consideration for the coach. While it was not possible to calculate the acute: chronic load within this study due to missing data, this would appear a suggestion for future research. In addition, this study only reports the external training load of field-based training, omitting internal response (e.g., session rating of perceived exertion, heart rate) which is only one component of the total exposure a player may experience. Also, this study did not account for the matches or resistance training that players were exposed to, which again should be a direction for future research to aggregate all load exposures. The findings from this study are also limited to one club, and their respective playing cohort, thus the generalisability of the data may be questionable. Saying that, this cohort were a Cup winning team during this respective season, thus the data presented can be used as a starting point for either future research or indeed the practitioner. The change in physical qualities of players were not quantified in this study, thus it is not clear if this specific strategies employed during this respective season were optimal for players to maintain aerobic fitness, speed and strength among other qualities during the nine month in-season period. Finally, future research should consider the periodisation of technical and tactical skills that occurs within successful teams, to develop knowledge of elite sport (28).

CONCLUSION

This was the first study to quantify the external training load, measured using GPS technology, across a professional rugby league season. The results found large reductions for training loads between preseason and in-season periods. Across the season, a small decrease in intensity (relative distance, absolute and relative total-HSR) was observed. Future research should quantify the adequacy of the training loads experienced by players, while considering the acute: chronic loads, fitness: fatigue models and the impact on performance and injury.

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Table 1. Mean external session training load of professional rugby league players at different times in the season

	Phase of the Season				RM ANOVA	*Post-hoc*
	Preseason	**Early**	**Mid**	**Late**		
Session Duration (min)	51.9 ± 5.0	35.8 ± 1.5	36.4 ± 2.7	37.5 ± 2.9	p<0.001	P > E, M, L
Total Distance (m)	3723 ± 265	2793 ± 404	2658 ± 196	2678 ± 213	p<0.001	P > E, M, L
Relative Distance ($m\cdot min^{-1}$)	72.6 ± 2.8	75.4 ± 6.9	74.4 ± 7.0	73.5 ± 5.0	p=0.338	
Walking (m)	1137 ± 258	829 ± 228	840 ± 235	869 ± 230	p<0.001	P > E, M, L
Jogging (m)	1240 ± 199	896 ± 75	884 ± 91	949 ± 87	p<0.001	P > E, M, L
Cruising (m)	570 ± 179	435 ± 141	411 ± 135	410 ± 125	p<0.001	P > E, M, L
Striding (m)	280 ± 187	210 ± 142	220 ± 196	176 ± 118	p=0.006	P > E, M, L
High-Speed Running (m)	286 ± 98	185 ± 59	194 ± 51	182 ± 63	p<0.001	P > E, M, L
Sprinting (m)	209 ± 78	147 ± 73	129 ± 65	93 ± 48	p<0.001	P & E > L
Total HSR (m)	496 ± 135	331 ± 48	323 ± 67	276 ± 78	p<0.001	P > E, M, L
Relative Total HSR ($m\cdot min^{-1}$)	9.8 ± 2.9	9.2 ± 2.6	9.2 ± 2.1	7.7 ± 2.1	p=0.064	

Table 2. Effect size (*d*) and *post-hoc* differences between mean external session training load of professional rugby league players at different stages of the season

	Preseason *vs.* Early	Preseason *vs.* Mid	Preseason *vs.* Late	Early *vs.* Mid	Early *vs.* Late	Mid *vs.* Late
Session Duration (mins)	*Very Large* (p<0.001; d=4.57)	*Very Large* (p<0.001; d=3.97)	*Very Large* (p<0.001; d=3.61)	*Small* (p=1.000; d=-0.26)	*Moderate* (p=0.636; d=-0.73)	*Small* (p=1.000; d=-0.39)
Total Distance (m)	*Very Large* (p=0.002; d=2.66)	*Very Large* (p<0.001; d=4.65)	*Very Large* (p<0.001; d=4.4)	*Small* (p=1.000; d=0.43)	*Small* (p=1.000; d=0.36)	*Trivial* (p=1.000; d=-0.10)
Relative Distance ($m \cdot min^{-1}$)	*Small* (p=0.385; d=0.51)	*Small* (p=1.000; d=-0.33)	*Small* (p=1.000; d=-0.23)	*Trivial* (p=0.739; d=0.14)	*Small* (p=1.000; d=0.31)	*Trivial* (p=1.000; d=0.15)
Walking (m)	*Large* (p=0.003; d=1.27)	*Large* (p=0.005; d=1.21)	*Moderate* (p=0.013; d=1.11)	*Trivial* (p=1.000; d=-0.05)	*Trivial* (p=1.000; d=-0.17)	*Trivial* (p=1.000; d=-0.12)
Jogging (m)	*Very Large* (p=0.026; d=2.38)	*Very Large* (p=0.026; d=2.38)	*Large* (p=0.012; d=1.97)	*Trivial* (p=0.983; d=0.15)	*Small* (p=0.251; d=-0.64)	*Moderate* (p=1.000; d=-0.72)
Cruising (m)	*Moderate* (p<0.001; d=0.85)	*Moderate* (p<0.001; d=1.02)	*Moderate* (p<0.001; d=1.06)	*Trivial* (p=1.000; d=0.17)	*Trivial* (p=0.095; d=0.19)	*Trivial* (p=0.485; d=0.01)
Striding (m)	*Small* (p=0.036; d=0.43)	*Small* (p=0.033; d=0.32)	*Moderate* (p=0.047; d=0.68)	*Trivial* (p=0.794; d=-0.06)	*Small* (p=0.221; d=0.26)	*Small* (p=0.687; d=0.27)
HSR (m)	*Large* (p=0.005; d=1.29)	*Large* (p=0.005; d=1.22)	*Large* (p=0.005; d=1.30)	*Trivial* (p=1.000; d=-0.17)	*Trivial* (p=1.000; d=0.05)	*Small* (p=1.000; d=0.22)
Sprinting (m)	*Moderate* (p=0.178; d=0.84)	*Large* (p=0.052; d=1.14)	*Large* (p=0.002; d=1.85)	*Small* (p=1.000; d=0.26)	*Moderate* (p=0.008; d=0.87)	*Moderate* (p=0.609; d=0.64)
Total HSR (m)	*Large* (p=0.015; d=1.37)	*Large* (p=0.011; d=1.68)	*Very Large* (p=0.002; d=2.05)	*Trivial* (p=1.000; d=0.10)	*Moderate* (p=0.193; d=0.60)	*Moderate* (p=0.814; d=0.65)
Relative Total HSR distance ($m \cdot min^{-1}$)	*Small* (p=1.000; d=0.21)	*Small* (p=1.000; d=0.22)	*Moderate* (p=0.185; d=0.82)	*Trivial* (p=1.000; d=-0.02)	*Moderate* (p=0.168; d=0.62)	*Moderate* (p=0.349; d=0.71)