Season-long increases in perceived muscle soreness in professional rugby league players: role of player position, match characteristics and playing surface

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Abstract

Rugby League (RL) is a high-impact collision sport characterised by repeated sprints and numerous high-speed impacts and consequently players often report immediate and prolonged muscle soreness in the days after a match. We examined muscle soreness after matches during a full season to understand the extent to which match characteristics influence soreness. Thirty-one elite Super League players provided daily measures of muscle soreness after each of the 26 competitive fixtures of the 2012 season. Playing position, phase of the season, playing surface and match characteristics were recorded from each match. Muscle soreness peaked at day 1 and was still apparent at day 4 post-game with no attenuation in the magnitude of muscle soreness over the course of the season. Neither playing position, phase of season or playing surface had any effects on the extent of muscle soreness. Playing time and total number of collisions were significantly correlated with higher ratings of muscle soreness, especially in the forwards. These data indicate the absence of a repeated bout effect or ‘contact adaptations’ in elite rugby players with soreness present throughout the entire season. Strategies must now be implemented to deal with the physical and psychological consequences of prolonged feeling of pain.

Keywords: DOMS, Pain, Performance, Rugby

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Introduction

Rugby League (RL) is an intermittent collision sport characterised by repeated bouts of high intensity activity (e.g. running and passing, sprinting, tackling) separated by bouts of low intensity activity (e.g. standing, walking, jogging) played over two forty minute halves. Teams comprise thirteen players who, depending on playing position and duration of game-time, cover distances in the range of 3,000-8,000 m during a match . RL players can be categorised into three groups based on commonalties in their playing role, these being: outside backs (full-back, wingers, centres), adjustables (stand-off, scrum-half, hooker loose forward), and hit-up forwards (props, second rows). Despite longer playing times for outside backs (~80 min) and adjustables (~65 min) compared to hit-up forwards (~44 min) , total distance covered relative to match time ($m \cdot min^{-1}$) is similar between positions (~90-95 $m \cdot min^{-1}$) . However, forwards (~1.0 min^{-1}) are involved in a higher frequency of physical collisions (tackle or being tackled) with opponents compared to outside backs (~0.3 min^{-1}) and adjustables (~0.6 min^{-1}) . Given the physicality of rugby match play and training, muscle soreness and/or damage is an inevitable outcome .

Delayed onset muscle soreness (DOMS) is an indirect marker of muscle tissue damage and presents as tender or aching muscles, usually felt during palpation or movement . DOMS is associated with unaccustomed muscular work, particularly when the exercise involves a high number of eccentric muscle contractions . Indeed, multiple accelerations and decelerations occur frequently during RL matches and training , movements that are known to cause structural damage to skeletal muscle tissue and its associated symptoms . Blunt force trauma from collisions is also a cause of tissue damage in rugby players that presents a strong association with DOMS in the days after matches . Prolonged increases in muscle soreness have implications for the quality of exercise performed by the player. For example, the strong influence of increases in muscle soreness on lowering exercise tolerance and inhibiting voluntary activation of muscle during force-related tasks can negatively influence the quality of strength and conditioning practices performed between games. Moreover, if players exhibit muscle soreness leading into the next match they are likely to underperform . The psychological consequences of prolonged feelings of pain might also have significant consequences given recent reports that some players can even become addicted to prescription pain killers .

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Many factors could potentially affect the magnitude of muscle soreness after RL games, including the number of high-speed collisions the playing position of the athlete and the playing surface . Understanding the effects of such factors on muscle soreness would enable coaches to make advanced modifications to training content in the days after matches to ensure players are appropriately managed.

Despite studies reporting symptoms of muscle soreness after RL matches, these have tended to focus on the response to a single match or training session . What is less clear is the muscle soreness response of elite players over the course of an entire playing season. Such studies are important given the potential reduction of muscle damage symptoms from repeated exposure to eccentric exercise via the 'repeated bout effect' . Similarly, tissue damage from collisions might subside as the season progresses because the player's body adapts to deal with blunt force trauma, known as 'contact adaptation' . Therefore practices to manage muscle soreness might differ depending on the phase of the competitive season.

To date there have been no studies that have attempted to quantify muscle soreness over the course of a full Super League season or attempted to identify factors that may contribute to the magnitude of the observed soreness. It is important to understand the temporal sequence of muscle soreness after competitive rugby league matches to allow periodized training plans to be developed. Therefore, the aims of this study were twofold: 1) to assess lower and upper body muscle soreness in a large cohort of elite Super League during the course of a Super League season; 2) to investigate the extent to which certain match characteristics influence lower and upper body muscle soreness in elite rugby league players.

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Methods

Participants and study design

Thirty-one professional rugby league players (mean ± *s* age 24.3 ± 3.7 years; height 179.4 ± 15.3 cm; body mass 98.8 ± 18.7 kg) who were part of the first team squad at a Super League Rugby club were recruited for this study. Based on previous studies, and in accordance with normal coaching practice, players were subcategorized into three positional groups of outside backs, adjustables, and hit-up forwards (referred to as forwards hereafter) . Where a player played in multiple groups throughout the season, the predominant position was selected for analysis. Data from 221 individual match performances were recorded, comprising 69, 36 and 116 performances for outside backs, adjustables and forwards, respectively. Each player was regarded free from illness and any known injuries due to the fact they were fit to play, however injury might have occurred during the match although this was not recorded and players were not excluded from post game data collection if injury did occur (except in the case of a major injury that resulted in the player taking time away from the club for surgery and/or rehabilitation). The win percentage for the season was 23% with the points *for* and *against* being 20 ±13 and 40 ±18, respectively. Coaches and players provided written and informed consent before commencing the study, with ethics approval granted by the Liverpool John Moores University Ethics Committee.

Data were collected from all 26 Super League fixtures during the 2012 season, comprising 101 and 120 individual player home and away performances, respectively. All home games were played on an artificial turf surface and away games on natural grass. Accordingly, analyses of home compared to away data enabled comparison of muscle soreness responses after matches on artificial versus natural turf. In accordance with previous studies in rugby league , muscle soreness data across three different time phases of the season were also considered; namely, early phase (4.0 ± 2.2 responses per player; 8 matches), mid-phase (4.4 ± 2.2 responses per player; 9 matches), and late phase (4.1 ± 2.3 responses per player; 9 matches). Players recorded lower and upper body muscle soreness values on match day and then at 1 (D1), 2 (D2) 3 (D3) and four (D4) days after. Total playing time and the number of offensive and defensive collisions for each player were also recorded from each match.

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Assessment of lower and upper body muscle soreness

Players individually provided ratings of muscle soreness of the upper and lower body using an online player Performance Management System (Rugby Squad, The Sports Office, UK). Based on the method reported by McLean et al. , each player rated upper and lower body muscle soreness daily with a number from 1 (severe pain) to 5 (no pain). Players were provided with thorough instructions on how to complete the test and used this scale routinely for approximately five months before the start of the study. This method has been used previously in studies examining perceptual ratings of muscle soreness in elite rugby league players .

Defensive and offensive collisions

The number of tackles made and the number of offensive collisions during a game was used as a marker of physical workload . During the game, each player's individual numbers of tackles and ball carries was recorded and made available to the team using 'Opta stats' software. A tackle was only recorded if the player has a major contribution to the execution of the tackle and therefore gives a good indication of physical impact. Tackles did not include missed tackles, which were discarded from the analysis given that the data from Opta cannot distinguish which missed tackles resulted in a collision or not. The number of carries only included carries that resulted in a collision from an opposing player through either the ball carrier being tackled by a defending player or the ball carrier going into a tackle and offloading the ball in the process of being tackled. The total number of collisions was calculated by summing the number of ball carries and number of tackles (although it should be stressed that some additional collisions resulting from missed tackles could have been disregarded using this method).

Statistics

Diagnostic tests (Shapiro-Wilk) were performed on the distributions of all the dependent variables and indicated that data did not meet the condition of normality. Where appropriate, changes in muscle soreness in

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the days after a match were analysed using separate Friedman analysis of variance hypothesis tests. Separate Friedman analysis of variance hypothesis tests were also employed to compare players' muscle soreness responses between early-, mid- and late-phases of the season. If required, *post-hoc* Wilcoxon paired ranks test were used to detect differences between the specific phases. Mann-Whitney tests were used to assess differences in lower and upper body soreness between artificial and natural turf. Kruskal-Wallis hypothesis tests were used to compare muscle soreness responses between positional groups and to compare match characteristics between positional groups. Where appropriate, *post-hoc* Mann-Whitney tests were used to locate differences between specific groups. In all multiple comparisons Bonferroni adjustments were applied to the alpha values to reduce the risk of a type I error. Descriptive statistics (median and inter-quartile range) were calculated for all variables. Relationships between muscle soreness and match characteristics were analysed using Spearman's Rank correlation. All statistical analysis was performed using the Statistical Package for Social Sciences (SPSS v 22.0, Surrey, UK). Statistical significance was set as $P<0.05$.

Results

Effect of playing position on post-match muscle soreness response

Lower and upper body soreness were greater than match day values for all positional groups at all time points ($P < 0.001$). However, only match day values for muscle soreness were different between groups ($P < 0.001$), with adjustables reporting less lower and upper body soreness than backs and forwards (all $P < 0.001$). Lower and upper body muscle soreness responses after matches for all positional groups can be seen in Table I.

****** Insert Table I here ******

Effect of playing phase on post-match muscle soreness response

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Irrespective of the playing phase, lower ($P<0.001$) and upper body muscle soreness ($P<0.001$) were higher at all measurement points after a match. Only lower ($P = 0.042$) and upper ($P = 0.009$) body muscle soreness recorded on match day was different between the playing phases. *Post-hoc* analyses revealed that early and late playing phases were different for lower body soreness ($P = 0.016$), whereas mid ($P = 0.014$) and late ($P = 0.007$) were both different to early playing phase upper body soreness. Lower and upper body muscle soreness responses during the early, mid and late playing phase are shown in Table II.

****** Insert Table II here ******

Playing surface

On both surface types lower ($P<0.001$) and upper body muscle soreness ($P<0.001$) were increased at all time points after a match. However, lower (all $P>0.05$) and upper body (all $P>0.05$) muscle soreness responses were not different between artificial or natural turf surfaces (Table III).

****** Insert Table III here ******

Match characteristics

There were differences in playing time between positions ($P<0.001$), with *post hoc* analysis revealing the shortest playing times for forwards followed by adjustables and then backs (all $P<0.001$). The number of defensive collisions was different between positions ($P<0.001$), with forwards doing more than backs and adjustables (both $P<0.001$), and adjustables more than backs ($P<0.001$). Offensive collisions were also different between positions ($P<0.001$), with adjustables completing less than backs and forwards (both $P<0.001$). The total collisions ($P<0.001$) and collisions per minute ($P<0.001$) were different, with forwards performing more of each compared to both backs and adjustables (all $P<0.001$). All data are shown in Table IV.

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Relationships between match characteristics and muscle soreness

There were relationships ($P<0.05$) between match characteristics and measures of lower and upper body soreness at D1-D4 when players were analyzed collectively and by position. Data are shown in Table V**.**

Discussion

For the first time we provide the most comprehensive data on the temporal pattern of upper and lower body soreness after a match in elite rugby league players, with data sampled from all matches during a Super League season. This study also provides data that explores the muscle soreness responses between rugby league matches played on artificial versus real turf. Several relationships between match characteristics and muscle soreness responses are also examined for individual player groups. Importantly, matches resulted in muscle soreness and players remained sore for four days after matches across the entire playing season. These data suggest that there is no repeated bout effect in elite rugby players and/or players do not adapt to blunt force traumas. Moreover, strategies should be implemented to help players overcome muscle soreness as well as deal with the consequences of prolonged periods of pain.

The immediate increases in perceived lower and upper body muscle soreness the day after a match followed by a steady return to match day values over the next three days is consistent with previous studies in rugby . That the values had not returned to match day values by day four also reaffirms that muscle soreness responses after matches are prolonged and typically outlast other symptoms of tissue damage . This finding is especially pertinent given that the intensity of training at the club typically tapered towards game day with a complete rest day usually being observed 2 days prior to the game and a very light skills based training session performed the day prior to a game. Whilst we postulate the primary causes of muscle soreness to be match-related activity, it is difficult to rule out additional soreness caused by the training content in the days between games, especially given that resistance training is a key component of the training regimen. This is supported by the low, albeit significant correlations observed between selected match characteristics and muscle soreness measures (Table III).

Adjustables reported less muscle soreness on match days than backs and forwards. This is likely a reflection of better perceived recovery by some players and that some positions in this group would have been exposed to less damaging exercise in the days leading up to the match. For example, halfbacks have ball playing and organisational responsibilities to co-ordinate and move a team around the field. As such, adjustables are typically protected from a high number of collisions in training and matches to minimise fatigue. There was, however, no difference in lower and upper body soreness responses between outside backs, adjustables and forwards in the days after a game. While this finding might seem unusual given that certain positions (i.e. forwards) were involved in more physical collisions that cause greater muscle soreness , these data are consistent with the only other study to examine muscle soreness in Super League players . Indeed, a greater number of lower and upper body collisions were observed for forwards compared to other positional groups and probably explains the stronger associations reported between match characteristics and muscle soreness. This means that other mechanisms were principally responsible for the increased muscle soreness of outside backs and adjustables, such as greater running demands and longer game time. Different positional demands imposed on rugby players during a match are likely to explain the variance in fatigue response between positions . Given that there could be differing mechanisms responsible for the pain in the backs and forwards, these data suggest that different treatment strategies might be useful. However, since the majority of muscle soreness research has used eccentric contractions to induce damage rather than blunt force trauma, strategies to deal with this in the literature are scarce and future research might wish to consider how to address this gap in the literature.

A key finding of this study was that lower and upper body soreness was not different between the early, mid and late phases of the season in the days after matches. Players also reported greater lower and upper body soreness on match day as the season progressed. Collectively these findings suggest professional rugby league players remained in a constant state of post match pain throughout the playing season and that they do not adapt to tolerate the effects of match demands as the season progresses. The repeated bout effect proposes that after an initial bout of muscle-damaging exercise, adaptation occurs to the muscle, whereby if the same bout of damaging exercise was repeated it would result in the symptoms of exercise-induced muscle damage being attenuated . While the blunt force trauma is likely to be a cause of soreness experienced by rugby players, this study supports the notion that the repeated bout effect does not occur in well-trained team sport players . We also contest the idea that players of collision sports develop a ‘contact adaptation’ .

Half of the games played by players in this study were on artificial turf while the remaining fixtures were played on normal grass. Artificial turf might potentially cause increased muscle soreness because of differences in shoe surface interaction and player movements when compared to normal grass. However, we report no difference in the soreness response reported between surface types. Notwithstanding the differences in movement and match characteristics between rugby codes, our findings are in contrast to those reported for rugby union where consistently small increases in muscle soreness were reported for four days after matches on artificial turf. Such findings might be expected given that Williams and colleagues only surveyed opposition players, meaning that higher soreness was reported in players unaccustomed to artificial pitches. The rugby league team in our study also lost 8/13 games played on artificial turf compared to the 1/12 games lost by the rugby union team. That successful teams perform more total distance, accelerations and high speed running , it is plausible that a greater external load in the successful rugby union team caused more tissue damage resulting in greater muscle soreness after matches. Alternatively, our study simply provides evidence to refute claims made by teams sport athletes who perceive greater soreness and longer recovery times after playing on artificial turf .

When positions were considered collectively, greater match time and total collisions were associated with the higher ratings of upper and lower body soreness reported after matches. The strong associations between game time and upper and lower body soreness have not been reported previously, but are likely to indicate an increased exposure to damaging exercise leading to more soreness. The association between total collisions and muscle soreness are, however, consistent with data previously reported in elite Super League players (Twist et al., 2012). The strongest correlations between the reported game characteristics and muscle soreness were reported for forwards, who had the highest number of collisions but shortest match time. As with the previous study (Twist et al., 2012), backs showed poor correlations between match characteristics and upper and lower body soreness despite reporting similar ratings of perceived soreness to other positional groups. This indicates that other mechanisms than those reported here contributed to perceived soreness in backs. More high intensity running and sprints that are also of longer duration and with increased decelerations might well explain the perceived soreness responses in backs.

The extensive reporting of muscle soreness for the entirety of the playing season in elite rugby league players presents challenges to coaches in terms of recovery practices, as well as implications for managing the long-term health and well being of players. More importantly, we demonstrate the willingness of players to accept pain over such extended periods of time and continue to play. These data support previous observations that have reported the normalization of pain as 'part of the game' in rugby league players . Future studies might wish to consider the long term health implications of continued exercise-induced pain in rugby players and the attitudes and actions taken by players and coaches to address this. It should also be stressed that the extensive reporting of muscle soreness occurred despite procedures being in place at the club aimed at maximinsimng recovery. For example, all players were required to use post game ice baths, they were given a standardised protein:carbohydrate recovery drink and a standardised post-game meal and attended a post-game swim/stretch session at a local swimming pool. The vast majority of the post-game recovery strategy was consistent across all players although massage was avaialable in the days following the match upon player request and this optionally addiitoanl therapy was not recorded in the present study.

In conclusion, the present study has for the first time quantified the temporal sequence of muscle soreness over a full Super League season. We report that players perceive to be constantly sore throughout the season, and that muscle soreness is still apparent four days after a match. Focussing attention towards strategies to relieve muscle soreness and investigation of wider issues regarding player health and wellbeing is important to support players in the long term.

Table Legends

Table I Measures (median and inter-quartile range) of lower and upper body muscle soreness for all positional groups on and for four days (D1-D4) after match day in elite rugby league players.

Table II Measures (median and inter-quartile range) of lower and upper body muscle soreness for four days (D1-D4) after match day during early, mid- and late phases of the season.

Figure III Measures (median and inter-quartile range) of lower and upper body muscle soreness for four days (D1-D4) after match day on artificial and grass surfaces. * indicates significant difference from Pre game.

Table IV Match characteristics (median and inter-quartile range) of backs, pivots and forwards during elite rugby league matches

Table V Correlations between match characteristics and lower and upper body soreness for backs, adjustables and forwards

Table I Median (inter-quartile range) of lower and upper body muscle soreness for all positional groups on and for four days (D1-D4) after match day in elite rugby league players.

	Match day	**D1 post**	**D2 post**	**D3 post**	**D4 post**
Lower body		#	#	#	#
Backs (n = 69)	4 (0.5)	2 (1)	3 (1)	3 (0.5)	4 (1)
Adjustables (n = 36)	5 (0.5)*‡	2 (1)	3 (1)	3 (0)	3 (1)
Forwards (n = 116)	4 (0)	2 (2)	3 (1)	3 (1)	3 (1)
Upper body		#	#	#	#
Backs (n = 69)	4 (2)	2 (1)	3 (1)	3 (1)	3 (1)
Adjustables (n = 36)	5 (1)*‡	2 (1)	3 (1)	3 (1)	3 (1)
Forwards (n = 116)	4 (1)	2 (2)	3 (2)	3 (1)	4 (1)

* indicates value significantly different to Backs, ‡ indicates significantly different to Forwards. # indicates muscle soreness values different to match day in all positions.

Table II Median (inter-quartile range) of lower and upper body muscle soreness for four days (D1-D4) after match day during early, mid- and late phases of the season.

	Match day	D1 post	D2 post	D3 post	D4 post
Lower body		#	#	#	#
Early Phase	4.5 (1)	2 (1.13)	2 (1)	3 (1.3)	3.3 (1)
Mid-Phase	4 (1)	2 (2)	3 (1)	3 (1)	3 (1)
Late-Phase	4 (0.5)*	2 (1.25)	3 (3)	3 (0)	3 (1)
Upper body		#	#	#	#
Early Phase	4.75 (1)	2 (2)	3 (1)	3 (1)	3 (1)
Mid-Phase	4 (1)*	2 (1)	3 (2)	3 (1)	4 (1)
Late-Phase	4 (1)*	2 (2)	3 (1)	3 (1)	3 (1)

* indicates value significantly different to Early Phase value. # indicates muscle soreness values different to match day.

Table III Measures (median and inter-quartile range) of lower and upper body muscle soreness for four days (D1-D4) after match day on artificial and grass surfaces. * indicates significant difference from Pre game.

	Match day	D1 post	D2 post	D3 post	D4 post
		#	#	#	#
Lower body					
Artificial surface	4 (1)	2 (1)	3 (1)	3 (0)	3 (1)
Grass surface	4 (1)	2 (1)	3 (1)	3 (0.5)	3 (1)
Upper body		#	#	#	#
Artificial surface	4 (1)	2 (2)	3 (1)	3 (1)	4 (1)
Grass surface	4 (1)	2 (2)	3 (2)	3 (1)	3 (1)

# indicates muscle soreness values different to match day.

Table IV Median (inter-quartile range) for match characteristics of backs, adjustables and forwards during elite rugby league matches

	Backs (n = 69)	**Adjustables (n = 36)**	**Forwards (n = 116)**
Playing time (min)	80 (0)*	80 (17)*‡	56 (41.5)
Defensive collisions (#)	8 (9.5)*	14 (12)* ‡	24 (13)
Offensive collisions (#)	9 (4)	4 (4)*‡	8.5 (5)
Total collisions (#)	19 (8.5)*	21 (12)*	32 (15)
Total collisions ($\# \cdot min^{-1}$)	0.3 (0.1)*	0.3 (0.3)*	0.6 (0.3)

* indicates values significantly different to Forwards; ‡ indicates values significantly different to Backs.

Table V Correlations between match characteristics and lower and upper body soreness for backs, adjustables and forwards

	Lower body soreness				**Upper body soreness**			
	D1	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**
Playing time (min)								
Backs	0.076	0.203	0.253*	0.218	-0.102	0.118	0.166	0.020
Adjustable	-0.308	-0.310	-0.095	-0.016	-0.255	-0.307	-0.225	-0.153
Forwards	-0.578*	-0.527*	-0.474*	-0.460*	-0.629*	-0.593*	-0.479*	-0.434*
All	-0.372*	-0.260*	-0.197*	-0.154*	-0.366*	-0.311*	-0.226*	-0.247*
Offensive collisions (#)								
Backs	-0.144	-0.188	-0.139	0.162	-0.090	-0.096	0.073	0.074
Adjustable	0.194	0.150	0.232	0.147	0.222	0.383*	0.350*	0.239
Forwards	-0.229*	-0.227*	-0.138	-0.202*	-0.263**	-0.313**	-0.109	-0.084
All	-0.109	-0.199*	-0.131	-0.110	-0.164*	-0.168*	-0.032	-0.008
Defensive collisions (#)								
Backs	-0.130	0.102	0.232	0.080	0.055	0.125	0.105	-0.068
Adjustable	-0.391*	-0.153	0.025	0.008	-0.132	-0.116	-0.367*	-0.145
Forwards	-0.305*	-0.182	-0.214*	-0.236*	-0.424*	-0.222*	-0.249*	-0.218*
All	-0.254*	-0.067	-0.045	-0.055	-0.247*	-0.069	-0.116	-0.101
Total collisions (#)								
Backs	-0.258*	-0.192	-0.098	0.136	-0.068	-0.082	0.036	-0.016
Adjustable	0.121	0.145	0.225	0.144	0.244	0.370*	0.290	0.261
Forwards	-0.303*	-0.250*	-0.159	-0.222*	-0.338*	-0.310*	-0.153	-0.111
All	-0.207*	-0.213*	-0.134*	-0.132	-0.229*	-0.177*	-0.065	-0.047

* indicates significant correlation

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