CHANGES IN BACK SQUAT BAR VELOCITY AND PERCEIVED MUSCLE SORENESS FOLLOWING A STANDARDISED RUGBY LEAGUE MATCH SIMULATION

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This study examined changes in back squat bar velocity and perceived muscle soreness following a rugby league match simulation protocol. Twenty male rugby league players (age: 19.8 ± 0.7 yrs) were recruited for this study. Back squat bar velocity and perceived muscle soreness of the lower body were collected on four days surrounding a match simulation: -24 h (prior to match simulation), +0 h (after the match simulation), +24 h and +48 h. Compared to baseline (-24h), there were non-significant decreases in maximum (d_z=-0.50, *moderate*) back squat bar velocity +0 h. There was a significant increase in perceived muscle soreness at +0h only (p=0.003). Results suggest that elevated muscle soreness may not indicate impaired neuromuscular performance and highlight the importance of monitoring fatigue via multiple measures to ensure appropriate coaching decisions are made.

KEYWORDS: neuromuscular fatigue, team sport, recovery, muscle soreness

INTRODUCTION: During an 80-minute rugby league match, players can cover over 8 km, including up to 1 km of high-speed running, and be involved in collisions with opposition players as often as 1.9 times per minute (Hausler et al., 2016). However, the physical demands of a match can vary significantly between individuals within the team and between matches (Hausler et al., 2016). Consequently, players will experience varying levels of fatigue according to the overall match demands, current health, and training status (Johnston et al., 2015). Monitoring neuromuscular status following a match may assist in ensuring a suitable balance of recovery and training stimuli is prescribed according to each player’s individual level of fatigue (Booth et al., 2017). While there are many tools to monitor fatigue, the use of field tests of neuromuscular function is favourable to identify functional changes that may impact performance (Reilly et al., 2009). Furthermore, the measure of choice must have valid and reliable, fit within the team’s training schedule, and not instil additional fatigue in the players (Starling et al., 2017).

In recent years there has been an increase in devices that accurately and reliably measure bar velocity during upper- and lower-body exercise (Callaghan et al., 2022). While limited research has examined the use of such devices to monitor fatigue in team sports, studies have found monitoring bar velocity to be effective for assessing neuromuscular status during resistance training (Weakley et al., 2022). Given resistance exercise forms a key component of training in rugby league players, measuring bar velocity, can be easily integrated into a team’s resistance training program with minimal interference, thus aligning with the recommendations of Starling et al. (2017). Therefore, the aim of this research is to examine changes in bar velocity during back squats in response to a match simulation protocol previously validated to reflect the physical demands of an elite rugby league match (Sykes et al., 2013).

METHODS: Twenty male semi-professional rugby league players training for the under 21s competition of the Queensland Rugby League (mean ± SD: age: 19.83 ± 0.79 yr; height: 181.96 ± 5.26 cm; body mass: 97.02 ± 10.42 kg) were recruited to participate in this study. Prior to participating players were informed of the potential risks and provided written informed consent to participate in the study. Furthermore, all participants were familiar with the back squat (back squat 1RM: 139.00 ± 20.57 kg; relative strength 1.44 ± 0.20 kg/body mass), as they perform this exercise regularly as part of their normal training regime.

Each participant performed four velocity testing sessions conducted over four consecutive days (-24h, +0h, +24h, +48h), with each session commencing at the same time of day (17:15 h; ± 30 minutes). The velocity testing sessions began with a 5-minute standardised warm-up consisting of mobilisation exercises and bodyweight squats. The testing protocol included three sets of back squats with increasing loads and 2 minutes of passive rest separating the three sets. The loads used for the testing protocol were calculated from 1RM values established as part of the team's pre-season strength testing. Initially, two warm-up sets were performed at 20% and 40% 1RM (three repetitions for each set). Following these warm-up sets, participants completed a visual analogue scale (VAS) to indicate their perceived lower-body muscle soreness during those sets. A 100 mm line depicting a scale of 0 (no soreness) to 100 (worst soreness possible) was marked to represent their perceived soreness (Mattacola et al., 1997; Callaghan et al., 2022). The velocity testing set was performed at 60% 1RM (three repetitions). Participants were instructed to perform all repetitions with a slow, controlled eccentric phase and the concentric phase completed as fast as possible to full extension. To ensure a consistent range of motion and performance of the back squat between sessions, participants were required to achieve a depth where their femurs were parallel to the ground. Additionally, markings were placed on the ground to ensure consistent foot placement between sessions. Mean concentric velocity of the bar was recorded for each repetition using the PUSH Band 2.0 (PUSH Inc., Toronto, Canada) affixed to the centre of the barbell, and connected to an iPad via Bluetooth using the PUSH application (version 4.6.2, PUSH Inc., Toronto, Canada). Data was stored in the cloud on the PUSH portal, then downloaded in a Microsoft Excel (Microsoft Corp, Redmond, WA, USA) spreadsheet for storage and analysis. The maximum mean concentric bar velocity from the three 60% 1RM repetitions was identified and used for analysis.

The match simulation protocol occurred on the second day with testing (+0h) performed within 30 minutes after the match simulation. Participants undertook a 5-minute standardised warm-up, followed by a validated rugby match simulation protocol (Skyes et al.,2013). The simulation consisted of two halves separated by 10 minutes of passive rest. Each half was 43.4 minutes in duration and consisted of 20 identical cycles that involved periods of standing, walking, jogging, sprinting, and simulated tackles (falls to and from the ground). An audio recording provided accurate timing throughout the simulation and verbal instructions were provided on the task to be performed (i.e., standing, walking, jogging, sprinting, and simulated tackles). During the match simulation, total distance covered and high-speed running (≥5m/s) distance were collected from a 5-Hz GPS device (Playertek, Catapult Group, Ireland) positioned between the scapulae via a form-fitting under-garment. In addition, heart rate data were collected using a chest-worn heart rate monitor (Polar H10; Polar Electro, Kempele, Finland). Rating of perceived exertion (RPE) was recorded at the end of each half.

For descriptive purposes of the match simulation, the total distance and high-speed running distance as well as the mean and maximum heart rate of the participants are presented (mean ± SD). To examine the post-match changes in the bar velocity and perceived muscle soreness (+0hr, +24hr, +48hr) from baseline measures (-24 h) *a priori* pairwise comparisons with an adjusted alpha level of 0.017 were performed. Cohen's d_z effect sizes (d_z) were calculated to quantify the magnitude of difference in all measures from baseline (-24 h) with d_z of 0.2, 0.5 and 0.8 regarded as small, moderate, and large effects, respectively. All analyses were undertaken using Statistical Package for the Social Sciences (v26.0, IBM Corporation, Somers, New York, USA).

RESULTS: During the match simulation, players covered a distance of 8562 ± 244 m, with 1154 ± 254 m classed as high-speed running (≥ 5 m/s). The average heart rate was 161 ± 10 bpm and maximum heart rate was 180 ± 10 bpm. Players perceived the match simulation to be an RPE of 4 ± 1 AU and 4 ± 2 AU for the first and second half, respectively.

Compared to baseline, small to moderate effect size decreases in back squat bar velocity were noted at each post-simulation timepoint. However, these changes were not statistically significant (+0 h: $t_{(19)}$=2.20, p=0.04, +24 h: $t_{(19)}$=0.96, p=0.35, +48 h: $t_{(19)}$=1.44, p=0.17; Figure 1). There was a statistically significant increase in perceived muscle soreness of the lower body from baseline at +0 h ($t_{(19)}$=-3.48, p=0.003), before returning to baseline measures at +24 h ($t_{(19)}$=-0.20, p=0.84), and +48 h ($t_{(19)}$=-0.11, p=0.91).

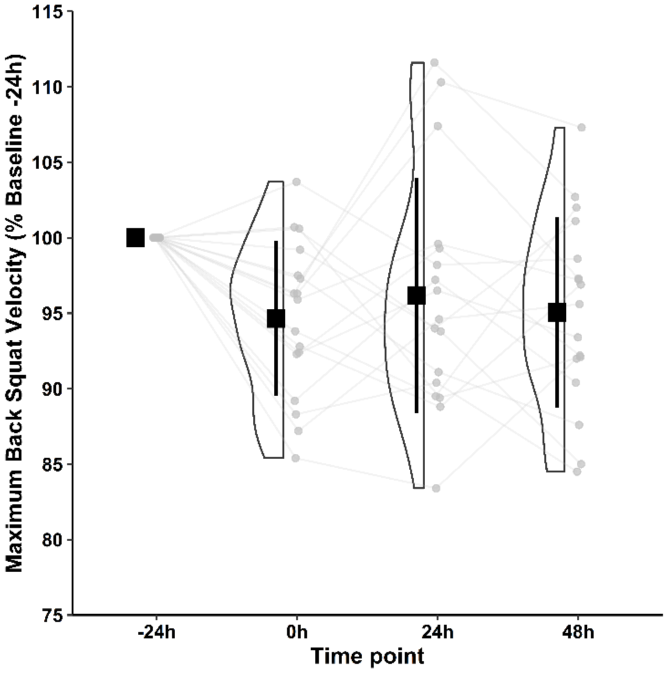

Figure *1:* Changes in maximum back squat bar velocity with 60% 1RM, relative to the first velocity testing session (-24 h). Individual data points (grey), mean ± SD (black), and violin plots are presented. Velocity from -24 h testing session was regarded as 100%.

DISCUSSION: Perceived muscle soreness of the lower body was found to be significantly greater immediately following the match simulation with *small* to *moderate* decreases in back squat bar velocity at +0 h compared to baseline (-24 h). However, no statistically significant changes in back squat bar velocity were found following the match simulation at any time point.

Previous literature has reported that the coefficient of variability for maximum back squat bar velocity measures at 60% 1RM loads is 2.87% (Callaghan et al., 2022). In the present study changes in back squat bar velocity at +0 h were 4.09 ± 9.00% lower than baseline and are likely to have been in response to the match simulation and not due to the expected variability of the velocity measures. This combined with *small* to *moderate* d_z changes in back squat bar velocity and lower body muscle soreness immediately following the match simulation suggests that some neuromuscular impairment may have been present but not substantial enough to produce statistically significant decreases in back squat bar velocity.

While there were no significant changes in bar velocity in the present study, there was a significant increase in perceived muscle soreness associated with performing the back squat. These results indicate that the degree of muscle soreness experienced by participants may not have been substantial enough to elicit a change in the bar velocity of their back squat and suggest that increased muscle soreness may not necessarily correspond to impaired neuromuscular performance. Twist et al. (2012) reported that following a rugby league match muscle soreness was significantly increased for at least 48 hours, but CMJ flight time was only impaired for 24 hours post-match. Thus, perceived muscle soreness may persist longer than impairments to neuromuscular performance and should be considered when monitoring the post-match recovery of players. These findings highlight the multifactorial nature of fatigue and the importance of monitoring the post-match recovery of players via multiple measures to ensure appropriate coaching decisions are made.

CONCLUSION: The match simulation was found to cause an increase in the perceived muscle soreness associated with performing back squats immediately afterwards only. Although there were *small* to *moderate* decreases in back squat bar velocity, there were no statistically significant changes in back squat bar velocity following the match simulation. Thus, the physical demands of the match simulation may have been insufficient to instil significant levels of fatigue in this population of semi-professional rugby league players. Additionally, the increased muscle soreness without a significant change in back squat bar velocity suggests that muscle soreness may not necessarily impact neuromuscular performance. Therefore, muscle soreness should be used in combination with other measures of neuromuscular fatigue to guide coaching decisions.

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