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Original research

Influence of physical contact on neuromuscular fatigue and markers of muscle damage following small-sided games

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ABSTRACT

Objectives: Physical contact is frequent in rugby league competition and is thought to be a major contributor to the fatigue and creatine kinase (CK) response, although direct evidence is lacking. The aim of this study was to investigate the influence that physical contact had on the fatigue and CK response to small-sided games.
Design: Cross-over, counter-balanced study.
Methods: Twenty-three junior elite rugby league players were divided into two groups. Group one played a contact game on day 1 before playing a non-contact game 72 h later; group two played the games in reverse order. The rules were identical for each game, with the only difference being a 10 s contact bout every 50 s during the contact game. Upper and lower body neuromuscular fatigue and blood concentrations of CK were assessed immediately before, immediately after, and 12 and 24 h after the games. During each game, players wore global positioning system units to provide information on movements.
Results: CK increased after both games, peaking immediately following the non-contact game; CK was still rising 24 h following the contact game. The difference between the two conditions was practically meaningful at this point (likelihood = likely, 82%; ES = 0.86). There were moderate to large reductions in upper body power following the contact game (ES = −0.74 to −1.86), and no reductions following the non-contact game.
Conclusions: This study indicates that large increases in blood CK and upper body fatigue result from physical contact. Training sessions involving physical contact should be performed well in advance of scheduled games.
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1. Introduction

Rugby league is a contact sport with periods of high- and low intensity activity.[1,2] During competition, players typically cover distances of 90–100 m min^{-1},[1–3] including 6–14 m min^{-1} at high-speeds.[1,2] In addition, to these running demands, players frequently engage in physical collisions during attack and defence. Players perform 24–47 contact efforts during a game or 0.38–1.09 per minute depending on position.[4]

Due to the demanding nature of rugby league, players experience considerable fatigue and increases of myofibre proteins within the blood, indicative of muscle damage,[5] following competition.[6–8] Physical collisions encountered during competition are thought to be a major contributor to this fatigue. Indeed, research from rugby league has reported positive relationships between the number of collisions performed during competition and increases in creatine kinase activity (CK), and lower body neuromuscular fatigue.[8–10] It is thought that the blunt force trauma associated with physical collisions results in skeletal muscle damage and reduced muscle function. In addition, one study has reported decrements in upper body neuromuscular function following rugby league competition.[11] The authors suggested that physical collisions may have been responsible for the increases in upper body fatigue, but this was not determined. Although these studies provide an insight into the potential role collisions play in the fatigue and muscle damage response, they do not show cause and effect.

Direct evidence supporting the relationships between physical contact, fatigue and muscle damage is far from substantive. Performing tackles in combination with repeated-sprints results in a greater heart rate and perceived effort than performing repeated sprints alone; however, whether there is any difference in the fatigue response following such activity is unclear.[12] One study has attempted to assess the impact of contact on fatigue following a team sport simulation.[13] Despite this, the authors reported

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no significant increase in CK following contact compared with no-contact. The contact involved players hitting tackle bags once every 3 min. Although controlled, this contact does not reflect the demanding nature or frequency of competition contact efforts.[3] As such, further evidence is required within a controlled environment utilising contact similar to that of competition to determine the impact collisions have on markers of fatigue and muscle damage.

Small-sided games (SSG) are regularly used in rugby league training in an attempt to replicate the demands of competition, providing players with a specific training stimulus and the opportunity to test skills under pressure and fatigue. Recent studies have shown that these games can elicit similar movement and skill demands,[14,15] as well as physiological responses seen during competition,[16] which directly translate into improvements in fitness and match performance.[17,18] These games can be either played with or without contact,[15] and therefore present a semi-controlled, yet ecologically valid platform to assess the influence of physical contact on fatigue and muscle damage following small-sided games. Therefore, the aim of this study was to assess the influence of physical contact on the fatigue and muscle damage response to SSG. Based on the current literature it was hypothesised that the addition of contact to SSG would result in greater upper body fatigue and muscle damage compared to SSG without contact.

2. Methods

A crossover, counterbalanced design was used. Neuromuscular fatigue, blood CK (an indirect marker of muscle damage), and perceived wellbeing were monitored before, immediately after, 12, and 24 h following 'offside' SSG with and without contact. Global positioning system (GPS) microtechnology devices were used to assess movements during the small-sided games. Players were randomly divided into two groups; one group played the small-sided game with no contact first followed by the small-sided game with contact 72 h later; the second group played the games in reverse order.

Twenty-three elite junior rugby league players (age 19.1 ± 0.8 years; height 178.3 ± 22.9 cm; body mass 93.7 ± 9.2 kg) from the same National Rugby League club participated in the study. One extra player participated in the games only (i.e. no fatigue or CK measurements) in order to equalise player numbers. Data were collected in the penultimate week of pre-season, with players free from injury and in peak physical fitness. Before the study, players received an information sheet outlining experimental procedures; written informed consent was obtained from each player. Over the course of the testing period, players were asked to maintain their normal diet. The study was approved by the University's ethical review board for human research.

Two SSG were performed in two training sessions separated by 72 h. Both games were 'offside' small-sided games, one with contact, and one without contact, regularly used by the coaches during training. Players were divided into 4 teams (each of 6 players); teams 1 and 2 played the non-contact game first and then the contact game 72 h later; teams 3 and 4 played the games in reverse order. Each game consisted of two 8 min halves separated by a 90 s rest interval played on a grass training pitch in a standardised ($30\text{ m} \times 70\text{ m}$) playing area. The 'offside' game permitted each team to have three 'plays' whilst in possession of the ball. A 'play' ended when the player in possession of the ball was touched by a defender with two hands. The ball was turned over when the attacking side had completed three 'plays'. Unlike a regular small-sided rugby game, during the 'offside' game, the ball can be passed in any direction (i.e. to 'offside' players). The only difference between the two games was the addition of 8, 10 s contact and wrestle periods during each half of the contact game. The players were asked to perform alternate shoulder pummels for 5 s, before being given 5 s to wrestle their partner onto their back. All players received coaching on wrestling techniques as part of their training and were familiar with this contact drill. Simulated contacts similar to those used in the present study have been shown to have good reproducibility in rugby league players.[12] After each contact period, the game resumed. Other than the 16 contact periods, there was no difference in the rules, verbal encouragement, pitch size, player number, and match duration between the contact and non-contact game.

Neuromuscular fatigue was assessed immediately before, immediately after, 12, and 24 h following each game. Lower body neuromuscular fatigue was assessed using a countermovement jump (CMJ); upper body neuromuscular fatigue was assessed using a plyometric press-up (PP), both of which are described previously.[11] Both exercises were performed on a force platform (Kistler 9290AD Force Platform, Kistler, USA) connected to a laptop (Acer Aspire 2930, Acer, UK) running manufacturer designed software (QuattroJump, Kistler, USA). Peak power and force were the dependant variables, and calculated as defined previously.[19] Previous research has reported typical error of measurement (TE) for CMJ peak power and peak force as 2.9% and 2.2% respectively.[19] The TE for the PP was 5.0% and 2.4% for peak power and peak force, respectively.

Whole blood CK was assessed at the same time points as neuromuscular fatigue as an indirect marker of muscle damage. After pre-warming of the hand, a 30 μl sample of blood was taken from a fingertip and analysed using a colorimetric assay procedure (Reflotron, Boehringer Mannheim, Germany). Before each testing session, the instrument was calibrated in accordance with the manufacturer recommendations.[8,20] The TE for CK was 3.3%.

Perceptual wellbeing was assessed in the first fatigue monitoring session of each day. This was assessed by the experimenter asking players to rate feelings of fatigue, muscle soreness, sleep quality, mood and stress on 0–5 Likert scales; the individual scores were summated to give an overall wellbeing score.[20] In addition, 30 min after each game, rating of perceived exertion (RPE) was recorded using the CR-10 RPE scale to rate how hard players perceived each game. Session RPE has been found to be a valid method of assessing internal load in rugby league players.[21]

Game movements were assessed by GPS microtechnology devices fitted between the shoulder blades of the manufacturer-provided vest. The GPS units sampled at 10 Hz (Team S4, Catapult Sports, VIC, Australia) and included 100 Hz tri-axial accelerometers, gyroscopes, and magnetometers to provide information on collisions. Data were downloaded to a laptop (Acer Aspire 2930, Acer, UK) and subsequently analysed (Sprint, Version 5, Catapult Sports, VIC, Australia). Data were categorised into low ($0\text{–}5\text{ m s}^{-1}$) and high speed ($\geq 5.1\text{ m s}^{-1}$) movement bands. Repeated high-intensity effort (RHIE) bouts were classified as 3 or more maximal acceleration ($\geq 2.78\text{ m s}^{-2}$), high-speed, or contact efforts with less than 21 s between each effort.[1] These units have been shown to offer a valid and reliable method of quantifying movements that are commonplace in rugby league.[22–24]

The differences in fatigue, muscle damage and running demands between the contact and non-contact games and changes over time were determined using traditional null hypothesis significance testing, and magnitude based inferences. In order to determine changes in neuromuscular function and blood CK, a two-way (condition × time) repeated measures ANOVA was used to determine the statistical significance of any differences. To compare differences in activity profiles between the contact and non-contact games, paired-samples *t*-test were used with a Bonferroni adjustment. These statistical tests were conducted using SPSS version 19 (SPSS for Windows, IBM Software, NY, USA). Based on the real-world relevance of the results, two statistical methods were used to determine the meaningfulness of any differences. Firstly,

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