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Section: Original Investigation

Article Title: The Effect of Different Repeated High-Intensity Effort Bouts on Subsequent Running, Skill Performance and Neuromuscular Function

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Journal: *International Journal of Sports Physiology and Performance*

Acceptance Date: July 16, 2015

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DOI: http://dx.doi.org/10.1123/ijspp.2015-0243

"The Effect of Different Repeated High-Intensity Effort Bouts on Subsequent Running, Skill Performance and Neuromuscular Function" by Johnston RD, Gabbett TJ, Jenkins DG, Speranza MJ
International Journal of Sports Physiology and Performance
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RUNNING HEAD: Repeated efforts and subsequent performance

The effect of different repeated high-intensity effort bouts on subsequent running, skill performance and neuromuscular function

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Word Count:

Abstract Word Count: 243

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Abstract

Purpose: To assess the impact of different repeated high-intensity effort (RHIE) bouts on player activity profiles, skill involvements and neuromuscular fatigue during small-sided games. ***Methods:*** Twenty-two semi-professional rugby league players (age 24.0 ± 1.8 years; body mass 95.6 ± 7.4 kg) participated in this study. During 4 testing sessions, players performed RHIE bouts that each differed in the combination of contact and running efforts, followed by a 5 min 'off-side' small-sided game before performing a second bout of RHIE activity and another 5 min small-sided game. Global positioning system microtechnology and video recordings provided information on activity profiles and skill involvements. A countermovement jump and a plyometric push-up assessed changes in lower- and upper-body neuromuscular function after each session. ***Results:*** Following running dominant RHIE bouts, players maintained running intensities during both games. In the contact dominant RHIE bouts, reductions in moderate-speed activity were observed from game 1 to game 2 (ES = -0.71 to -1.06). There was also moderately lower disposal efficiencies across both games following contact dominant RHIE activity compared with running dominant activity (ES = 0.62-1.02). Greater reductions in lower-body fatigue occurred as RHIE bouts became more running dominant (ES = -0.01 to -1.36), whereas upper-body fatigue increased as RHIE bouts became more contact dominant (ES = -0.07 to -1.55). ***Conclusions:*** Physical contact causes reductions in running intensities and the quality of skill involvements during game-based activities. In addition, the neuromuscular fatigue experienced by players is specific to the activities performed.

Key Words: Team sport; rugby league; movement demands; pacing; global positioning system; fatigue

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Introduction

Collision based team sports such as rugby league and rugby union are characterised by high-intensity running and contact efforts interspersed with periods of lower-intensity activity.[1,2] Whilst the majority of match-play is spent performing low-intensity activities,[1] high-intensity activities typically occur at critical periods and often in close proximity to one another.[3,4] These intense bouts of activity have been termed repeated high-intensity effort (RHIE) bouts.[4] Specifically, a RHIE bout involves 3 or more contact, acceleration, or high-speed running efforts with less than 21 seconds between each effort.[5] Although 3 efforts is the minimum number required to constitute a RHIE bout, these bouts can be much more frequent and longer in duration.[6,7] The longest RHIE bout reported in a study of elite rugby league players included 13 efforts (4 contact and 9 acceleration) over a 120 s period with an average recovery time of 5 s between efforts.[7] Not only do these RHIE bouts occur frequently during rugby league [3,7] and union competition,[6] they also tend to occur during critical periods of play such as when defending the try-line.[3] Moreover, winning teams perform more RHIE bouts, more efforts per bout, and maintain a higher playing intensity whilst recovering from high-intensity efforts.[8] Clearly, the frequency of RHIE bouts and the critical time points at which they occur suggests players must have the capacity to maintain physical, technical and decision-making performance following these efforts in order to deliver successful outcomes.

Previous research has highlighted that the addition of contact efforts to repeated-sprints[9] and small-sided games[10-12] leads to greater reductions in running performance and increases in perceived effort compared with activities involving running alone.[9,10] Not only does physical contact result in transient fatigue, residual fatigue is also apparent, with increases in upper-body fatigue and muscle damage following contact small-sided games.[13] Conversely, increased running loads result in greater increases in lower-body fatigue.[13] Whilst previous studies have highlighted reductions in running following ‘contact only’

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RHIE bouts[11,12], players from both rugby codes rarely perform contact in isolation during match-play, rather they are interspersed with running efforts.[6,7] Therefore, it is important to determine whether subsequent running activity and fatigue is influenced by the type of RHIE bout performed (i.e. contact or running dominant).

Although physical performance is important,[14] skill and technical performance is inextricably linked to game success.[15] One study demonstrated that pivots showed reductions in the frequency and quality of skill involvements following the most intense 5 min running period during elite rugby league games.[16] In addition, tackle technique appears reduced following RHIE bouts.[17] Despite this, the specific effect RHIE bouts have on skill performance and whether this is dependent on the type of RHIE bout performed remains unknown. Given that RHIE bouts often occur during vital passages of play,[3] it is important to investigate the impact of RHIE bouts on both physical and technical performance. This would allow coaches to develop specific repeated effort drills that would develop players' ability to maintain skills under pressure and fatigue. With this in mind, the aims of this study were to determine the impact of different RHIE bouts on (1) running intensities (2) skill involvements and (3) neuromuscular fatigue during small-sided games. It was hypothesised that increasing the contact demands of the RHIE bouts would result in greater reductions in running intensity and more upper-, but less lower-body fatigue. In addition, skill performance would be negatively impacted by performing RHIE bouts.

Methods

Design

In order to test our hypotheses, a counter-balanced, cross-over experimental design was used. Players took part in 4 different RHIE bouts followed by small-sided games over 21 days; each session was separated by 7 days. Players wore global positioning system (GPS)

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microtechnology units during the RHIE bouts and small-sided games in order to provide information on activity profiles. Additionally, each small-sided game was filmed to assess the quality and frequency of skill involvements.

Subjects

Thirty-eight semi-professional rugby league players (age 24.2 ± 2.3 years; body mass 96.1 ± 10.9 kg) from the same Queensland Cup club, participated in the study. Data were collected during weeks 9-11 of the pre-season period, with players free from injury. Over the course of the testing period, players were asked to maintain their normal diet. In accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki), players received an information sheet outlining experimental procedures; written informed consent was obtained from each player. The study was approved by the University's ethical review board for human research. Over the course of the study, some players were unavailable for each testing session. Only players that completed each of the 4 conditions were used within the analysis. Therefore, 22 players (age 24.0 ± 1.8 years; body mass 95.6 ± 7.4 years) formed the final cohort for this study.

Protocol

On each of the 4 testing sessions, players performed 3 RHIE bouts followed by a standardised 5 minute 'off-side' small-sided game before repeating the RHIE bouts and small-sided game (Figure 1). Within 30 min following the RHIE bouts and games, neuromuscular function was assessed via a countermovement jump (CMJ) and plyometric push-up (PP). Players trained in two separate squads with one squad performing the testing first, immediately followed by the second squad of players. Prior to the first session, each squad was divided into two teams of nine players, ensuring an even spread of playing positions. Whilst every attempt was made to maintain the makeup of the teams across each of

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the 4 conditions, due to player absences (e.g. injury, separate training) some variations in the players within each team did occur between conditions. The number of players on each team was maintained at 9 for each condition.

RHIE Bouts

Prior to each small-sided game, players performed 3 x 6-effort RHIE bouts. Each bout lasted for 1 minute and involved 6 efforts with 30 s recovery between each bout where players jogged 20 m at their own pace. Following the third RHIE bout and the 20 m jog, there was an additional 30 s of recovery prior to the start of the small-sided game. These bouts were designed to reflect the work-to-rest ratios of the most demanding RHIE bouts observed in competition.[4,14] The 4 different RHIE bouts involved a combination of 5 s contact and/or 20 m sprint efforts with a 1:1 work-to-rest ratio. The 4 bouts comprised (1) 'all contact' (6 contact efforts), (2) 'all running' (6 20 m sprints), (3) 'mainly contact' (4 contact, 2 sprint efforts), and (4) 'mainly running' (2 contact, 4 sprint efforts) (Table 1). From a standing position, the contact efforts involved a hit on each shoulder, utilising over- and under-hook grips, before attempting to wrestle their opponent onto their back from a standing position. The 20 m sprint involved an all-out sprint followed by a 10 m deceleration.

Small-Sided Games

One minute following the third RHIE bout, the first small-sided game was played. The small-sided games were 5 min in duration and involved 9 vs. 9 players on a standardised (68 m x 40 m) floodlit grassed playing area. Unlike a regular small-sided rugby game, during 'off-side' games, the ball can be passed in any direction (i.e. to 'off-side' players). The 'off-side' game used the same rules as those reported previously.[10]

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Activity Profiles

Game and RHIE activity profiles were assessed using GPS microtechnology devices. The GPS units sampled at 10 Hz (Optimeye S5, Catapult Sports, VIC, Australia) and included a 100 Hz tri-axial accelerometer and gyroscope to provide information on collisions. Data were downloaded to a laptop and subsequently analysed (Sprint, Version 5.1.1, Catapult Sports, VIC, Australia). Data were categorised into low-speed activity (0-3.5 $m \cdot s^{-1}$), moderate-speed running (3.6-5.0 $m \cdot s^{-1}$) and high-speed running (≥5.1 $m \cdot s^{-1}$).[1] Player Load™ Slow (<2 $m \cdot s^{-1}$) was used to determine the load associated with the non-running components (i.e. physical contact) of the RHIE bouts.[18] These units offer valid and reliable estimates of activities common in team sports.[19,20] To assess internal load of each condition, within 30 min following the session, rating of perceived exertion (RPE [CR-10]) was recorded for each player.[21]

Skill Involvements

Each small-sided game was filmed using a video camera (Cannon Legria HV40, Japan). Games were coded for number of possessions, number and quality of disposals, and number of errors. An effective disposal was classified as a completed pass to a team-mate in an ‘open’ position; an ineffective disposal involved a pass that went to a closely marked team-mate or the ball was turned over.[22] Disposal efficiency represented the number of effective passes divided by the total number of possessions. An error was coded when the ball went to ground, or was intercepted. The test re-test reliability (typical error of measurement [TE]) was determined by the same operator coding two games on two separate occasions, 4 weeks apart for number of possessions (TE = 3.2%), number of disposals (TE = 5.7%), quality of disposals (TE = 4.3%), and percentage of errors (TE = 9.9%).

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Neuromuscular Fatigue

Neuromuscular fatigue was assessed within 15 min after the second game. Lower-body neuromuscular fatigue was assessed using a CMJ; upper-body neuromuscular fatigue was assessed using a PP as described previously.[23] Both exercises were performed on a force platform (Kistler 9290AD Force Platform, Kistler, USA) connected to a laptop running manufacturer designed software (QuattroJump, Kistler, USA). Changes in neuromuscular fatigue were compared against each player's maximum value that was determined 5 days prior to the first testing session. Maximum peak power was determined by their highest score from 3 CMJ's and PP's performed in a non-fatigued state, with approximately 5 min between efforts. The between day TE for the CMJ and PP was 3.5% and 3.8% for peak power, respectively.

Statistical Analysis

Based on the real-world relevance of the results, magnitude based inferences were used to determine the meaningfulness of any differences in activity profile, skill, and neuromuscular fatigue changes during and following the different RHIE bouts and games. Firstly, the likelihood that changes in the dependent variables were greater than the smallest worthwhile change was calculated as a small effect size of 0.20 x the between subject standard deviation. Thresholds used for assigning qualitative terms to chances were as follows: <1% almost certainly not; <5% very unlikely; <25% unlikely; <50% possibly not; >50% possibly; >75% likely; >95% very likely; ≥99% almost certain.[24] The magnitude of difference was considered practically meaningful when the likelihood was ≥75%. Secondly, magnitudes of change in the dependent variables were assessed using Cohen's effect size (ES) statistic.[25] Effect sizes (ES) of 0.20-0.60, 0.61-1.19, and ≥1.20 were considered small, moderate and large respectively.[26] Data are reported as means ± SD.

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Results

RHIE Bouts

Players covered an average of 43 ± 2 m·min^{-1} in the 'all contact', 49 ± 2 m·min^{-1} in the 'mainly contact', 84 ± 4 m·min^{-1} in the 'mainly running', and 105 ± 7 m·min^{-1} in the 'all running' RHIE bouts (ES = 3.00-12.97). In addition, Player Load^{TM} Slow values per minute of each bout were 7.6 ± 1.7 AU·min^{-1} ('all contact'), 5.0 ± 1.0 AU·min^{-1} ('mainly contact'), 4.0 ± 1.0 AU·min^{-1} ('mainly running'), and 2.6 ± 0.5 AU·min^{-1} ('all running') (ES = 1.77-3.99).

Game Intensities

In game 1, there were similar running intensities in each condition other than the 'all running' condition where the relative intensity was moderately lower than the 'all contact' (ES = -0.69 ± 0.22; likelihood = 93%, likely) and 'mainly contact' (ES = -0.69 ± 0.43; likelihood = 89%, likely) conditions (Figure 2). There was little difference between the relative intensities of game 2 for the different conditions. From game 1 to 2, there were only small and trivial reductions in the 'mainly running' (ES = -0.36 ± 0.62; likelihood = 83%, likely) and 'all running' (ES = -0.17 ± 0.23; likelihood = 87%, likely) conditions. There were however larger, moderate reductions in relative intensity in game 2 in the 'all contact' (ES = -0.96 ± 0.42; likelihood = 94%, likely) and 'mainly contact' (ES = -1.07 ± 0.34; likelihood = 94%, likely) conditions. These reductions were largely brought about by decreases in moderate-speed activity in game 2 in the 'all contact' (ES = -0.71 ± 0.34; likelihood = 93%, likely) and 'mainly contact' (ES = -1.06 ± 0.48; likelihood = 89%, likely) conditions. Albeit small, there were greater relative distances covered in game 2 of the 'mainly running' condition compared to all other conditions (ES = 0.34-0.38).

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Skill Involvements

During game 1, there were a total of 67, 79, 79, and 73 passes made in the 'all contact', 'mainly contact', 'mainly running', and 'all running' conditions. In game 2, there were a total of 58, 81, 66, and 73 passes made in the 'all contact', 'mainly contact', 'mainly running', and 'all running' conditions. There was no difference in the number of effective passes between conditions in game 1. In game 2, there were moderate increases in the number of effective passes across all conditions except in the 'all contact' condition where there was a small reduction in effective passes compared with game 1 (ES = -0.30 ± 0.22; likelihood = 77%, likely [Figure 3]). In game 1 there were moderately greater disposal efficiencies in the 'mainly running' (ES = 0.77-1.02) and 'all running' (ES = 0.62-0.79) conditions, compared with the games following the contact dominant conditions. There was little difference in skill performance between game 1 and game 2 in any condition although there was still greater disposal efficiencies observed in the game in the 'mainly running' (ES = 0.73 ± 0.19; likelihood = 97%, very likely), and 'all running' (ES = 0.83 ± 0.22; likelihood = 100%, almost certain) conditions compared with the 'mainly contact' condition. There were no differences in the number of errors between games or conditions.

Neuromuscular Fatigue

There was no change in CMJ peak power following the 'all contact' (ES = -0.01 ± 0.11; likelihood = 29%, possibly not), small reductions following the 'mainly contact' (ES = -0.33 ± 0.18; likelihood = 64%, possibly), moderate reductions following the 'mainly running' (ES = -1.02 ± 0.21; likelihood = 79%, likely), and finally large reductions following the 'all running' condition (ES = -1.36 ± 0.20; likelihood = 85%, likely). Furthermore, the reductions observed following the 'all running' and 'mainly running' conditions were moderately greater than the changes following the 'all contact' conditions (ES = 0.68-0.85).

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There were large reductions in PP peak power following the 'all contact' (ES = -1.55 ± 0.44; likelihood = 100%, almost certain) and 'mainly contact' (ES = -1.37 ± 0.32; likelihood = 100%, almost certain) conditions, moderate reductions following the 'mainly running' condition (ES = -0.92 ± 0.65; likelihood = 56%, possibly), and finally trivial reductions following the 'all running' condition (ES = -0.07 ± 0.09; likelihood = 36%, possibly). Reductions observed following the 'all contact' and 'mainly contact' conditions were moderately greater than the changes following the 'all running' (ES = 1.12-1.27) and 'mainly running' (ES = 0.66-0.88) conditions.

Perceived Exertion

The highest RPE was observed following the 'mainly contact' condition (RPE = 5.6 ± 1.1 AU), this reflected a large effect size difference compared with the 'all contact' (ES = -1.21 ± 0.23; likelihood = 100%, almost certain; RPE = 4.2 ± 1.3 AU) and 'mainly running' (ES = -1.41 ± 0.28; likelihood = 100%, almost certain; RPE = 4.0 ± 1.1 AU) conditions, and a moderate difference compared with the 'all running' condition (ES = -0.78 ± 0.18; likelihood = 92%, likely; RPE = 4.6 ± 1.5).

Discussion

The aims of this study were to determine the impact of different RHIE bouts on running intensities and skill involvements during game-based activities and to assess the neuromuscular fatigue response to RHIE bouts comprising different amounts of contact and sprinting. Players set a lower, but 'even-paced' pacing strategy in the 'all running' condition compared with the other conditions. When players were required to perform contact in the RHIE bouts, they began with higher running intensities in game 1, before showing reductions in game 2. These reductions were greater following the contact dominant conditions. As such, when players are required to perform contact dominant RHIE bouts they show greater

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reductions in running intensities compared to following running dominant RHIE activity. Furthermore, following contact dominant RHIE activity, players display lower quality skill involvements than following running dominant RHIE activity. Lower-body and upper-body fatigue appear to increase with both the running and contact demands of RHIE activity, respectively. This study demonstrates that physical contact causes greater reductions in running intensities and the quality of skill involvements during game-based activities compared with running efforts.

Different running intensities were observed during the small-sided games following the different RHIE bouts. Particularly in game 1, following the 'all running' condition, player work rates were reduced compared to the other conditions. They appeared to set an 'even-paced' pacing strategy that they could maintain across both game 1 and game 2.[27] The reason for this reduced intensity following the 'all running' bouts may be due to players being unaccustomed to exclusively performing running efforts given the high frequency of physical collisions during match-play.[1,10] In the other conditions, players employed a 'positive' pacing strategy whereby the playing intensity was high to begin with (i.e. in game 1) before decreasing in game 2; indicative of player fatigue.[27] These reductions in intensity were greater in game 2 following the contact dominant RHIE bouts, primarily through reductions in moderate-speed activity. These results are in accordance with others that have reported greater reductions in both high-speed,[9,11] and moderate-speed running[12] with increased contact demands. These findings clearly demonstrate the large physical cost associated with performing contact efforts. It is interesting to note that the greatest RPE was observed in the 'mainly contact' condition where players had to perform 4 contact and 2 running efforts per RHIE bout. It is likely that combining the demanding nature of contact efforts with the cardiovascular stress of running is particularly demanding for players and resulted in a greater RPE than the other conditions. Given the intense contact demands of competition,

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players should be regularly exposed to RHIE bouts involving contact in order to minimise reductions in player work-rates and deliver successful performances. A combination of running and contact efforts is more game-specific and likely to elicit greater internal loads.

Other than in the 'all contact' condition, where small reductions were observed, players showed moderate increases in the percentage of effective passes from game 1 to game 2. There are a number of potential explanations that could explain these findings. Firstly, players may be more accustomed to their team-mates, and opposition's style of play following game 1 allowing for improved passing performance. Secondly, a reduction in game speed, allowing players more time to make the correct decision and therefore deliver an effective pass could also have played a role. Whilst this may be the case in game 2 in the 'mainly contact' and 'mainly running' conditions, following the 'all running' RHIE bout, from game 1 to 2, the relative intensity was unchanged yet there was a marked increase in the percentage of effective passes. As such, an alternate explanation could be that as players were accustomed to performing this skill under pressure and fatigue, they were able to withstand higher levels of arousal, before arousal had detrimental effects on skill performance.[28] Indeed, previous research from water polo indicates that during high levels of exertion and fatigue, response accuracy on a sport-specific decision making test is increased, and shooting accuracy is maintained despite reductions in shooting technique.[29] Similarly, soccer players appear to be able to maintain skill performance over the course of a game despite reductions in physical performance and apparent fatigue.[30]

There was little change in the total number of passes per player between game 1 and game 2 following any of the RHIE bouts. Collectively, these results are in contrast to previous research from rugby league that reported reductions in the number and quality of skill involvements following the peak 5 min period during match-play.[16] A reason for this disparity could be due to the nature of the games, with the current study employing 'off-side'

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games that were shorter in duration as opposed to the ‘on-side’ nature and longer duration of rugby league competition. Despite this, there was reduced disposal efficiency in the games following contact dominant RHIE bouts compared to those following the running dominant bouts. This reduced disposal efficiency was largely brought about by players being caught in possession more frequently in the games following the contact dominant RHIE bouts. This could be due to higher levels of upper-body fatigue observed currently, and previously,[13] resulting in players being unable to complete fast exchanges in passes and therefore being caught in possession more frequently. Further research is required to determine the influence of RHIE activity and fatigue on technical and decision making performance in more closely controlled, sport specific ‘on-side’ scenarios in rugby players.

Greater increases in lower-body fatigue following the ‘all running’ RHIE bouts and games and progressively smaller increases in lower-body fatigue as the running loads of the RHIE bouts reduced were also observed. The opposite was observed for upper-body fatigue which increased with the contact demands. These findings are in accordance with those previously published[13] and clearly highlight that the fatigue response to players involved in contact sport is likely to be whole body in nature. Simply determining lower-body muscle fatigue is likely to underestimate the fatigue response. Furthermore, this provides useful information to coaches with players covering greater running loads during competition (i.e. outside backs) likely to experience more lower-body fatigue. Conversely, players who perform larger numbers of contact efforts (i.e. the forwards) are likely to suffer more upper-body fatigue in the days following competition. Further research should aim to elucidate specific training and recovery strategies following competition according to the activities performed by each player, based on their in-game positional demands.

It is important to note that this study was not without its limitations. Firstly, whilst we attempted to maintain the same work-to-rest ratios of 1:1 for both the 5 s contacts and the 20

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m sprints in the RHIE bouts, players typically completed the 20 m sprints in 3-4 seconds, and therefore had a slightly longer rest period (6-7 seconds). Secondly, the wrestle efforts were more eccentric/isometric in nature compared to the concentric dominant running efforts, which is likely to impact fatigue symptoms. Thirdly, the placement of the unit between the shoulder blades could influence the measurement of Player Load™ and might explain some of the differences observed between the contact and running RHIE bouts.[31] The placement of the GPS unit between the shoulder blades may be more sensitive for detecting accelerations that occur in the upper body (i.e. contact) rather than the lower body (i.e. running).

Practical Applications

Players should be exposed to a combination of contact and running RHIE bouts to prepare them for the intense demands of rugby league and rugby union competition. These bouts should be tailored to the specific positional demands of the game and reflect the differing contact and running demands between positional groups. Challenging players to maintain performance following RHIE activity may be an effective method of developing their ability to work under pressure and fatigue. Targeting opposition playmakers whilst in attack, making them perform more contact efforts, may lead to greater reductions in their physical and technical performance. Given the demanding nature of RHIE bouts and contact[9,13] the prescription of any RHIE training should take this into account and be appropriately periodised in order to maximise the adaptive response to training. Future research should aim to determine the efficacy a period of RHIE training has on players' ability to limit the physical and technical reductions observed following RHIE bouts. The fatigue response to rugby league training and competition is likely to be whole-body in nature and this, along with their match activities, should be taken into account when monitoring fatigue and prescribing training in players.

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Conclusions

When the activities performed in RHIE bouts are manipulated, players will set different pacing strategies in order to complete set tasks. When players are required to perform contact efforts, they set a positive pacing strategy where they start with an initially high playing intensity that is reduced in the second game. These reductions in running intensity are greater in the games following contact dominant RHIE bouts. In addition, whilst there are increases in the effective passes from game 1 to game 2 in all conditions other than the 'all contact' condition, there is reduced disposal efficiency observed in the games following the contact dominant bouts. Increases in running loads results in greater lower-body fatigue, whereas greater contact loads leads to increased upper-body fatigue. This study highlights the physical and functional cost of performing contact efforts from both a physical and technical perspective.

Acknowledgements

The authors have no conflicts of interest to declare, and no sources of funding were used in this study. Thanks to the players from Norths Devils RLFC who volunteered to take part in the study and the cooperation of the coaching staff throughout the data collection period.

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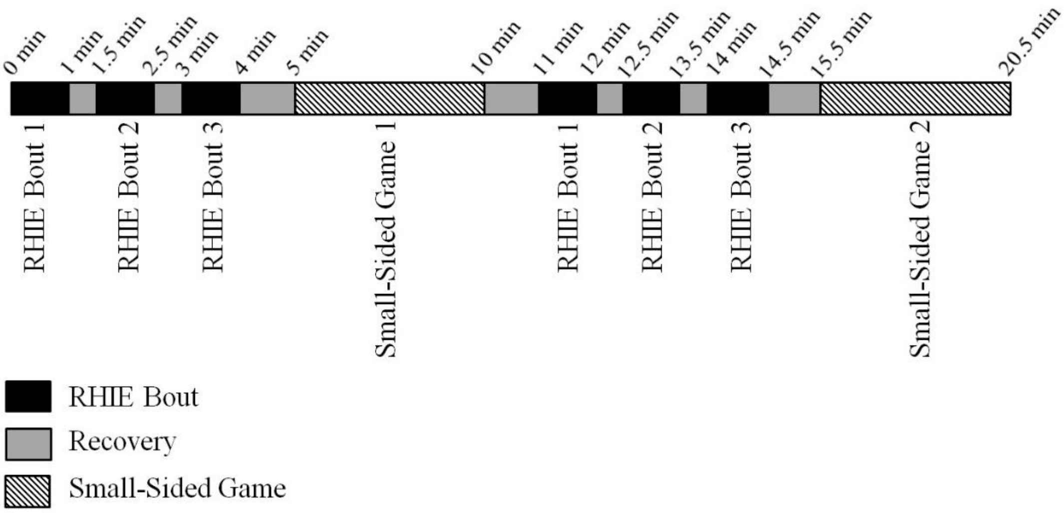

Figure 1. A schematic representation of the experimental protocol.

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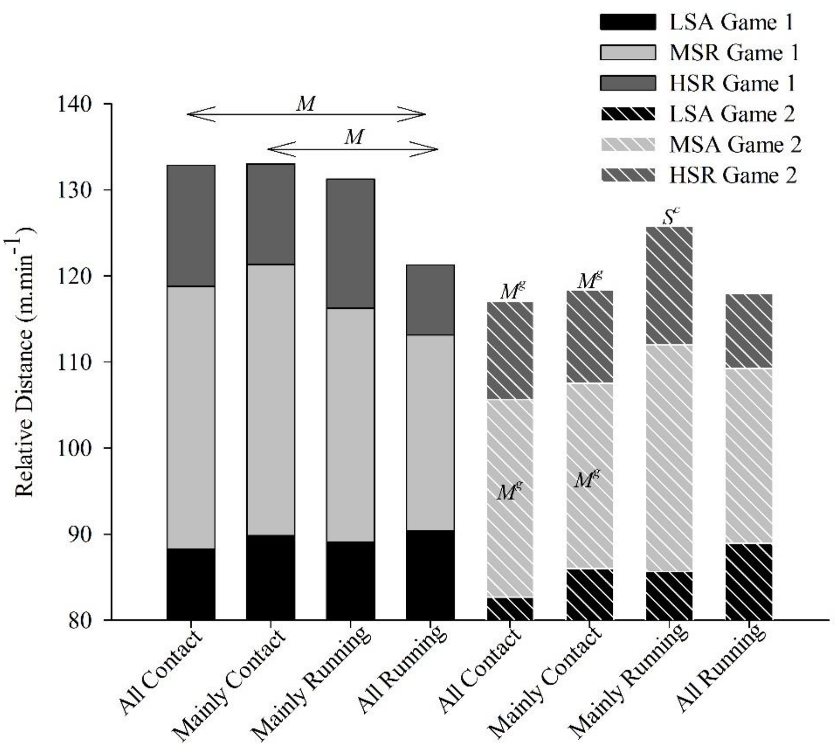

Figure 2. Movement demands of game 1 and game 2 following the different repeated effort bouts. LSA = low-speed activity; MSR = moderate-speed running; HSR = high-speed running. M^g refers to a moderate (0.61-1.19) effect size difference between game 1 and 2; S^c and M^c refers to a small (0.20-0.60) and moderate effect size difference between conditions. Data are presented as means ± SD.

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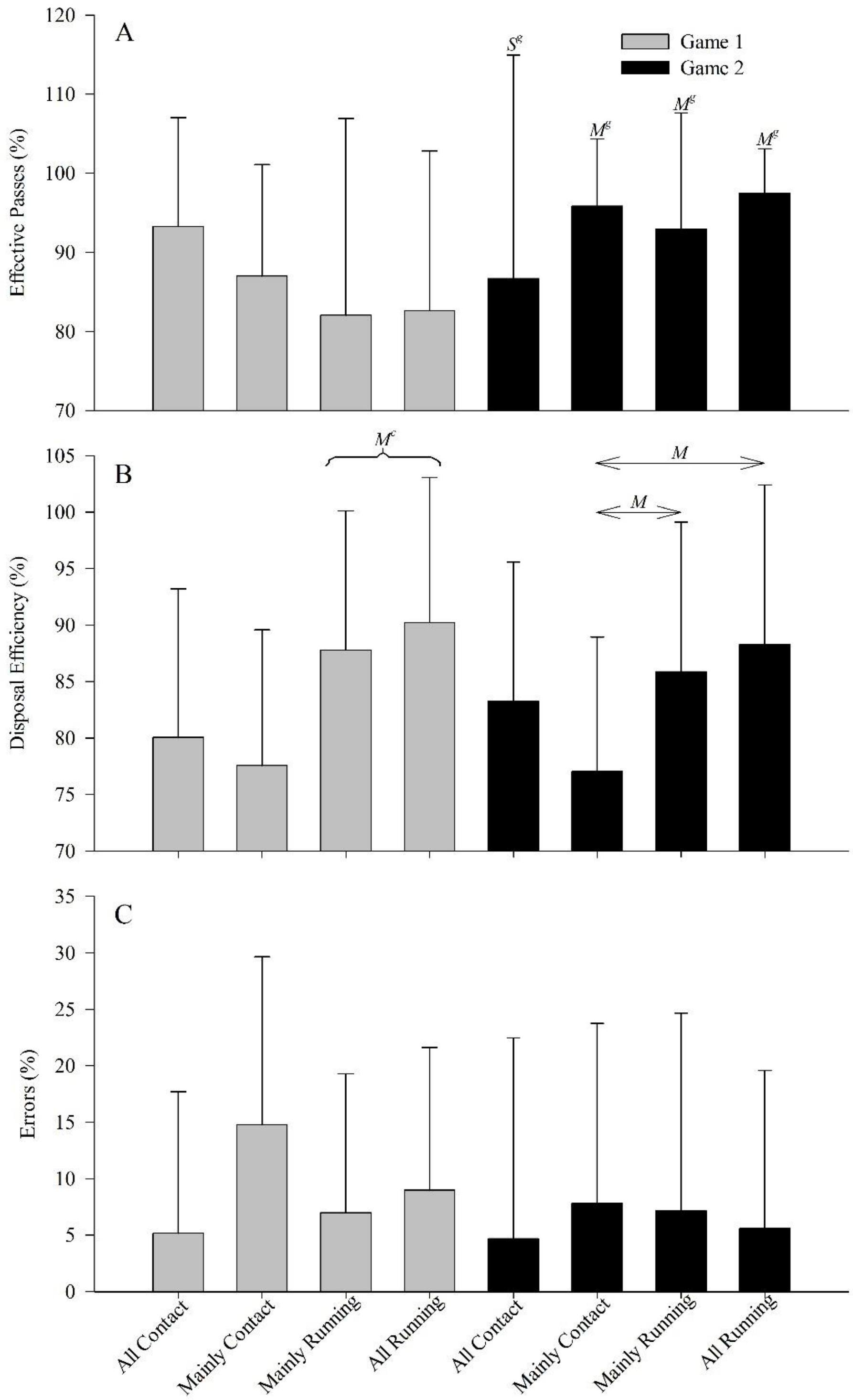

Figure 3. Skill performance during game 1 and 2 following the different repeated effort bouts. S^g, and M^g refers to a small (0.20-0.60) and moderate (0.61-1.19) effect size difference between game 1 and 2; M^c refers to a moderate effect size difference between conditions. Data are presented as means ± SD.

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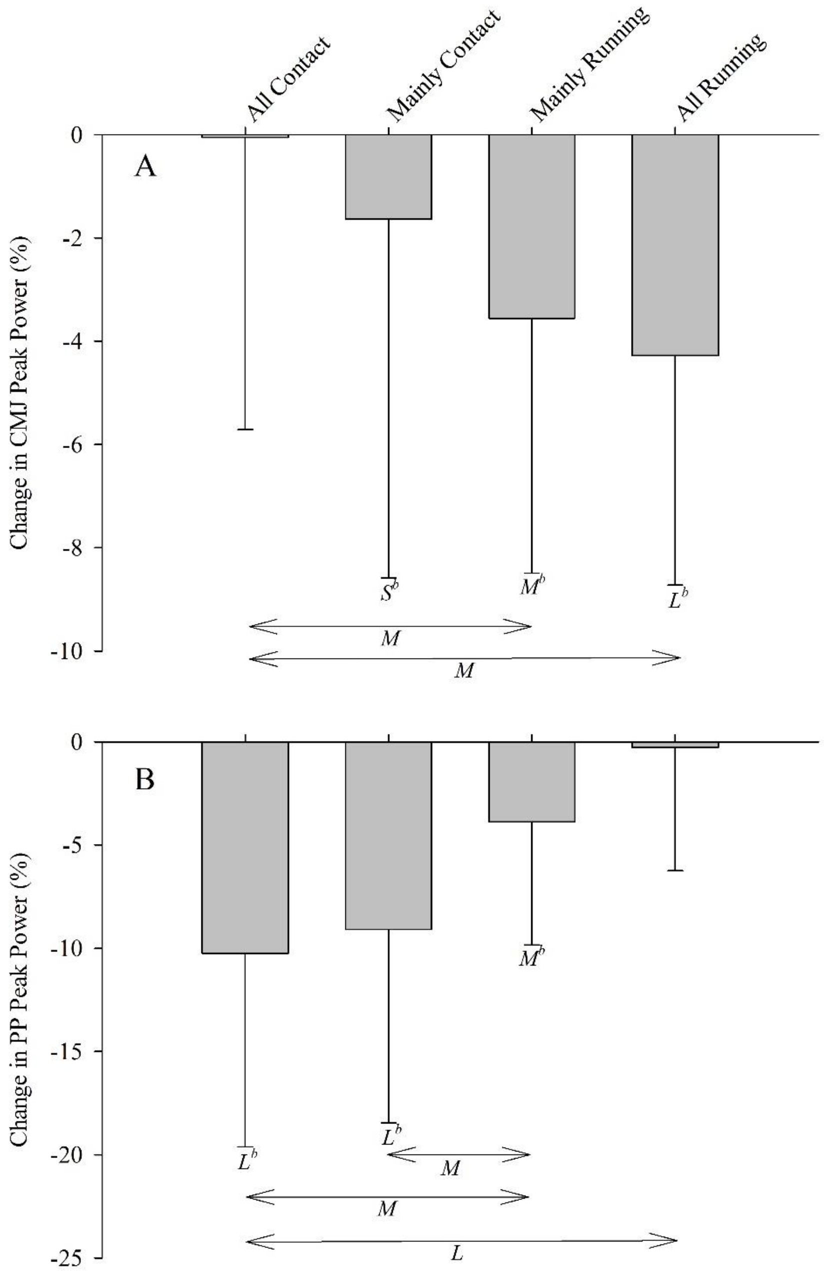

Figure 4. Changes in (A) lower body muscle function and (B) upper body muscle function following the different repeated effort bouts and small-sided games. CMJ = countermovement jump; PP = Plyometric push-up. S^b, M^b, and L^b refers to a small (0.20-0.60), moderate (0.61-1.19) and large (≥1.20) effect size difference from baseline; M^c and L^c refers to moderate and large effect sizes between conditions. Data are presented as means ± SD.

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Table 1. Activities performed during each RHIE bout preceding the small-sided games. †

RHIE Bout	Activities	Order of Efforts per Bout
All Contact	6 x 5 s contact and wrestle efforts on a 10 s cycle	C-C-C-C-C-C
All Running	6 x 20 m sprints on a 10 s cycle	R-R-R-R-R-R
Mainly Contact	4 x 5 s contact and wrestle efforts on a 10 s cycle 2 x 20 m sprints on a 10 s cycle	C-C-R-C-C-R
Mainly Running	2 x 5 s contact and wrestle efforts on a 10 s cycle 4 x 20 m sprints on a 10 s cycle	R-R-C-R-R-C

† RHIE = repeated high-intensity effort; R = running effort; C = contact effort.