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Article Title: Predictors of Repeated High-Intensity Effort Ability in Rugby League Players

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Predictors of Repeated High-Intensity Effort Ability in Rugby League Players

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ABSTRACT

Purpose: This study investigated the relationship between repeated high-intensity effort (RHIE) ability and selected physical qualities in rugby league players. Methods: Sixteen rugby league players underwent measurements of upper-body strength (4 repetition maximum [RM] bench press, weighted chin-up, weighted dips), upper-body muscular endurance (body-mass maximum repetition chin-up, body-mass maximum repetition dips), lower-body strength (4RM squat), estimated maximal aerobic power (multi-stage fitness test), and repeated high-intensity effort ability. The RHIE ability test consisted of 1 x 10 m sprint, 3 x full contact 1-on-1 tackling efforts, and a 30 m jog recovery. Players performed 4 repetitions of the test, with each repetition completed in 40 s. During the RHIE test, the speed of players was evaluated with a 10 m sprint effort while the movement of players was recorded using a wearable microtechnology device. 2D Player Load™ was used to quantify the collision component of the test. Results: Speed decrement was lower for the First (-2.4 ± 1.0%) than the Second Grade (-4.7 ± 2.1%) players. Players with greater initial speed had a higher average speed over the 4 sprints (r = 0.75), while players with greater maximum repetition dips maintained a higher 2D Player Load™ (r = 0.76). Conclusions: These findings demonstrate a relationship between well-developed acceleration and upper-body muscular endurance qualities and RHIE ability in rugby league players. Training programs designed to develop acceleration and upper-body muscular endurance are likely to improve RHIE ability.

KEY WORDS: repeated-effort; collision; contact sport; tackling; repeated-sprint
Introduction

Repeated-sprint ability is widely accepted as a critical component of high-intensity, intermittent team sports (e.g. soccer, hockey, water polo).\textsuperscript{1-3} The repeated-sprint demands have been shown to be greater during international than domestic and national level soccer matches.\textsuperscript{1} Furthermore, the majority of repeated-sprint bouts have been reported to occur in close proximity to goals scored and conceded, leading to the suggestion that the ability, or inability to perform repeated-sprints may prove critical to the outcome of the game.\textsuperscript{2,4}

Although repeated-sprint ability is important for sports such as hockey and soccer, the physical demands of collision sports (e.g. rugby league, rugby union, and Australian football) are increased through the large numbers of contact efforts (e.g. tackling and wrestling) players are required to perform during a match. These activities, which often involve multiple tackles, sprints, and accelerations with minimal recovery (~6 s) between efforts\textsuperscript{5} have been referred to as repeated high-intensity effort (RHIE) bouts.\textsuperscript{4,5} The importance of RHIE ability to collision sports is well established. Firstly, while repeated-sprint bouts occur infrequently in sports such as rugby league (on average 1 repeated-sprint bout performed per player per match), RHIE bouts are common (on average 9 repeated-effort bouts performed per player per match).\textsuperscript{6} Secondly, it has been shown that the addition of tackles and wrestling periods to repeated-sprints, resulted in greater reductions in sprint performance, and higher heart rates and ratings of perceived exertion than repeated-sprinting in isolation.\textsuperscript{7} Finally, the frequency and intensity of RHIE bouts performed during match-play has been shown to discriminate between winning and losing teams,\textsuperscript{8} elite senior and youth teams,\textsuperscript{9} trial and fixture matches,\textsuperscript{9} and junior teams of different playing standards.\textsuperscript{10}

Given the importance of repeated-sprinting and RHIE to competitive performance, tests to assess these physical qualities have grown in popularity. These tests have evolved from laboratory tests performed on cycle ergometers\textsuperscript{11} to game-specific tests that replicate the
specific movement patterns, recovery activities and durations, and work:rest ratios of match-play.\textsuperscript{12,13} Spencer et al.\textsuperscript{13} developed a test that employed 6 x 30 m sprints, with a 40 m active recovery, performed on a 25 s cycle and reported that the test offered a reliable assessment of repeated-sprint ability. Others have shown that tests of repeated-sprint ability are also capable of discriminating soccer players of higher and lower playing standards.\textsuperscript{12} More recently, tests of RHIE ability have been developed for volleyball\textsuperscript{14} and rugby league and union\textsuperscript{15} players. Sheppard et al.\textsuperscript{14} demonstrated that a RHIE test employing jumping, blocking, and lateral movement activities was capable of validly and reliably assessing repeated-effort performance in volleyball players. Austin et al.\textsuperscript{15} also developed a RHIE test for rugby league forwards. The test involved repeated-sprinting (9 x 20 m sprints performed on a 20 s cycle) and required players to repeatedly tackle (2 x 5 tackles, with each tackle separated by 20 s) a stationary 11 kg tackle bag. While this study was the first attempt to assess rugby league RHIE ability using a field test, given the prolonged recovery between tackling efforts (i.e. ~20 s) and the low mass of the tackle bag (i.e. 11 kg), it is unlikely that this test adequately assessed the RHIE demands of rugby league match-play in a game-specific manner.

Several studies have investigated the relationship between repeated-sprint ability and selected physical qualities (e.g. speed, aerobic power).\textsuperscript{12,16,17} Of the studies that have been performed, repeated-sprint performances have been strongly associated with speed\textsuperscript{12,17} and performance on the Yo-Yo intermittent endurance test (Level 2).\textsuperscript{16} These findings suggest that improvements in repeated-sprint ability may occur through both speed and high-intensity endurance training. To date, only one study has investigated the relationship between physical qualities and performances on a RHIE test; neither speed or high-intensity intermittent running ability were related to RHIE ability.\textsuperscript{15} While these findings demonstrate that RHIE ability is a different quality to both speed and high-intensity intermittent running
ability, given the large degree of physical contact involved in a RHIE bout, it is likely that other physical qualities (e.g. strength) could be associated with RHIE performance. An understanding of the physical qualities that contribute to RHIE ability may provide insight into appropriate training programs to improve RHIE performances. With this in mind, the purpose of this study was to investigate the relationship between RHIE ability and measurements of speed, aerobic power, upper and lower body strength, and endurance in rugby league players.

Methods

Design

This project was completed in 3 phases. Firstly, the RHIE demands of rugby league match-play were investigated using global positioning system (GPS) devices. Secondly, based on the results of the time-motion analysis, a game-specific RHIE test was developed to reflect the most extreme demands of competition in terms of number of efforts, duration of efforts, and recovery between efforts. Validity of the test was established by comparing RHIE results between First Grade and Second Grade rugby league players. Finally, the relationship between selected physical qualities (i.e. speed, aerobic power, high-intensity intermittent running ability, and upper and lower body strength, and endurance) and RHIE ability was determined using Pearson product moment correlation coefficients.

Subjects

Sixteen rugby league players (mean ± SD age, 24 ± 3 yr) participated in this study. Subjects were hit-up forwards from either a First Grade (N = 8; mean ± SD age, 25 ± 3 yr) or Second Grade (N = 8; mean ± SD age, 23 ± 3 yr) semi-professional rugby league team. Hit-up forwards were selected due to the high contact and RHIE demands associated with this playing position. At the time of study, players had completed 8 weeks of pre-season training, were in good physical condition, and free from injury. All participants received a
clear explanation of the study, including information on the risks and benefits, and written consent was obtained. All experimental procedures were approved by the Institutional Review Board for Human Investigation.

**Fitness Testing Battery**

Players underwent fitness testing over a two-week period in February as part of their pre-season training program for the forthcoming playing season. Testing was conducted two weeks before the first competition match. The physical tests performed were (i) 4 repetition maximum (RM) bench press, (ii) 4RM squat, (iii) 4RM weighted chin-up, (iv) 4RM dips, (v) body-mass maximum repetition chin-up, (vi) body-mass maximum repetition dips, (vii) multi-stage fitness test, and (viii) RHIE test. All testing was conducted at the same time of day (~ 6.00 pm). Participants were requested to abstain from strenuous physical exercise for 72 hours before testing, with only light skills, and minimal strength and conditioning performed in this period. Players performed no physical activity in the 24 hours prior to testing. Players were also instructed to consume their normal pre-training diet and to ensure adequate hydration at the time of testing.

**Upper-Body Muscular Strength**

Maximum upper-body strength was assessed using a 4RM bench press exercise, weighted chin-up, and dips. For the bench press, athletes used a free-weight Olympic-style barbell. Players lowered the bar on to the chest, and were required to fully extend their arms for the lift to be counted as a valid trial. Players were not permitted to bounce the bar off their chest and the feet were required to remain in contact with the ground, and buttocks in contact with the bench for the trial to be considered valid.

The 4RM weighted chin-up was added to the testing battery to assess the strength of the shoulder extensors. The 4RM weighted chin-up was determined by adding the athlete’s body mass to an additional mass which was attached to the athlete. The chin-up test was
performed with a supinated grip and begun with an eccentric phase. The trial was considered successful if the athlete fully extended their arms in the eccentric phase and was able to pull their body upwards to return to the starting position.

The 4RM weighted dip was the final test of upper-body strength. Players were required to place their hands on the parallel dip bars with an overhand grip, and lower themselves so that their chest was in line with the bars. The trial was considered successful if the athlete fully extended their arms in the concentric phase and was able to push their body upwards to return to the starting position.

**Upper-Body Muscular Endurance**

Players’ strength-endurance was assessed using maximum repetition chin-up and dip tests. Using their body mass as resistance, athletes were encouraged to perform as many repetitions as possible until fatigue.

**Lower-Body Muscular Strength**

Maximum lower-body strength was assessed using a 4RM full-squat exercise performed using a free-weight Olympic-style barbell. After warming up with progressively heavier loads, the athlete attempted their 4RM. Players were required to lower their body so that their thighs were past parallel with the floor, and fully extend the hip and knee joints for the trial to be considered valid.

**Maximal Aerobic Power**

Maximal aerobic power was estimated using the multi-stage fitness test. Players were required to run back and forth (i.e. shuttle run) along a 20m track, keeping in time with a series of signals on a compact disk. The frequency of the audible signals (and hence, running speed) was progressively increased, until volitional exhaustion was reached.
Maximal aerobic power (\(\bar{VO}_2\text{max}\)) was estimated using regression equations described by Ramsbottom et al.\(^1\)

**Repeated High-Intensity Effort Protocol**

The results of the time-motion analysis have been reported previously.\(^5\) In brief, the maximum number of efforts within a RHIE bout was 13. These consisted predominantly of acceleration and contact efforts. The mean effort duration was 2.1 s and the mean maximal effort duration was 6 s. The mean recovery time between efforts was 6.4 s (giving an exercise-to-rest ratio of ~1:1). The duration of the bout was 160 s. Based on the results of the time-motion analysis, the developed test consisted of (i) 1 x 10 m sprint (performed on a 6 s cycle), (ii) 3 x full contact 1-on-1 tackling efforts on a similar sized partner (the ball-carrier wore a chest shield, with each tackle lasting 4 s, and performed on a 6 s cycle), and (iii) a 30 m active recovery (jog ~13 s) back to the starting position. Players were provided a 3 s count-down before performing the next repetition. Players were required to perform 4 repetitions of the test, with each repetition completed in 40 s (Figure 1). For each contact effort, the tackler was required to move a distance of no further than 3 m (approximate distance travelled when making a tackle from marker), and the ball-carrier was instructed to run aggressively, and at speed towards the tackler.

**Speed and 2D Player Load\(^TM\)**

During the RHIE test, the speed of players was evaluated with a 10 m sprint effort using dual beam electronic timing gates (Swift Performance Equipment, New South Wales, Australia). All tests were conducted outdoors on a grass surface. Players assumed a crouched start position, with the front foot in line with the first timing gate. The movement of players was recorded using a wearable microtechnology device (Catapult Innovations, Melbourne, Australia) sampling at 10 Hz. The microtechnology unit included tri-axial
accelerometers and gyroscopes sampling at 100 Hz, to provide information on physical collisions. Vertical acceleration has been shown be highly correlated with running activities. 2D Player Load™ was used to eliminate the vertical load associated with running, in order to quantify the collision component of the test. The unit was worn in a small vest, on the upper back of the players.

**Data Reduction**

The 10 m sprint times were converted to a speed and the average speed over the four sprints was calculated. A theoretical “ideal” speed (assuming no decrement in sprint performance) was calculated by identifying the fastest sprint over the four repetitions. Total 2D Player Load™ for the 12 tackles (3 tackles in each repetition) was calculated. As with “ideal” speed, an “ideal” 2D Player Load™ (assuming no decrement in tackling performance) was calculated by identifying the highest 2D Player Load™ over the four repetitions, and multiplying that value by four. The percentage decrement in speed and 2D Player Load™ was calculated by dividing the average speed (or total 2D Player Load™) by the ideal speed (or 2D Player Load™), multiplying by 100, and then subtracting 100.

**Test-Retest Reliability**

Prior to performing this study, the test-retest reliability of the RHIE test was established. Seven players performed the RHIE test on two occasions, one week apart. The coefficient of variation for average speed and total 2D Player Load™ was 0.1 s (1.7%) and 0.7 arbitrary units (0.5%), respectively.

**Statistical Analysis**

Differences between the First Grade and Second Grade players for estimated VO₂ max, muscular strength and endurance, and RHIE performance (i.e. total sprint time, 2D Player Load™, and percentage decrement in speed and 2D Player Load™) were compared
using independent $t$-tests. Differences in ratings of perceived exertion after each cycle of the test were compared using a two-way (group x time) analysis of variance with repeated measures. The source(s) of any significant differences involving multiple groups were followed up using a Tukey honestly significant difference post hoc test. Cohen’s effect size (ES) statistic was also used to assess the magnitude of any between-group differences. Effect sizes of <0.2, 0.2-0.6, 0.61-1.2, 1.21-2.0, and >2.0 were considered trivial, small, moderate, large, and very large, respectively. The relationship between selected physical qualities (i.e. speed, aerobic power, and upper and lower body strength, and endurance) and RHIE ability was determined using Pearson product moment correlation coefficients. Correlations of 0.10-0.29, 0.30-0.50, 0.51-0.70, and >0.71 were considered small, moderate, large and very large, respectively. All data are reported as mean ± SD.

**Results**

**Repeated High-Intensity Effort Test**

The percentage decrement in 2D Player Load™ (-17.5%, range = -5.4% to -37.6%) was considerably greater than the percentage decrement in speed (-3.5%, range = -1.3% to -8.6%). There were small differences (p>0.05) between First and Second Grade players for speed (ES = 0.60) and 2D Player Load™ (ES = 0.57) at the beginning of the RHIE test. Moderate differences (ES = 1.03) were found between groups for total 2D Player Load™ at the completion of the test, although these differences were not statistically significant (p>0.05). However, the percentage speed decrement was greater (p=0.01) for the Second Grade players (-4.7 ± 2.1%) than the First Grade players (-2.4 ± 1.0%) (Table 1). Although not statistically significant (p>0.05), the First Grade players had a lower RPE after each cycle of the test (ES = 0.24 to 0.92) (Figure 2).
Running Qualities and Upper and Lower Body Strength, and Muscular Endurance

The estimated \( \dot{VO}_2 \text{max} \) and strength, and muscular endurance results for the First and Second Grade players are shown in Table 1. There were no significant differences (p>0.05) between groups for any of the tests of physical qualities.

Relationship between Selected Physical Qualities and Repeated High-Intensity Effort Ability

The relationships between selected physical qualities and RHIE test performance for the entire 16 players are shown in Table 2. Players with greater initial speed had a higher average speed over the 4 sprints, but also had the greatest decrement in speed. Players with greater maximum repetition dips maintained a higher 2D Player Load™ over the course of the test.

Discussion

This is the first study to develop a game-specific RHIE test for rugby league that replicates the most demanding passages of match-play. Given the frequency and importance of collisions to RHIE ability, we developed a test that included these events and used technology to measure performance during these activities. The results of our study demonstrate that the RHIE test was capable of discriminating higher and lower skilled players. Moreover, large positive associations were found between acceleration qualities and average speed (r = 0.75), and upper-body muscular endurance qualities and total 2D Player Load™ (r = 0.76) over the course of the test. These findings demonstrate that the developed test offers a valid protocol for the assessment of RHIE ability. Furthermore, the ability to maintain greater speed and 2D Player Load™ is associated with well-developed acceleration and upper-body muscular endurance qualities. Training programs designed to develop acceleration and upper-body muscular endurance is likely to improve RHIE ability.
A two-phase approach was used to establish the validity of the developed test. Firstly, the RHIE demands of rugby league match-play were investigated using microtechnology devices. Using this approach, we established that RHIE bouts consisted predominantly of acceleration and contact efforts. The large numbers of collisions, involving blunt force trauma performed in a RHIE bout, ensured that any developed test included these activities. While previous attempts to develop RHIE tests for rugby have involved tackling a lightweight (11 kg) tackle bag, the ecological validity of the present study is enhanced through the full-contact nature of the test, whereby players were required to repeatedly tackle opponents of ~100 kg. Given this activity replicates the exact conditions required of players during match-play, it is likely that the ensuing fatigue is also comparable to that experienced during match conditions. Secondly, RHIE ability was the only physical quality to discriminate between higher and lower skilled players, with only trivial to moderate differences found between groups for speed, aerobic power, muscular strength, and endurance. Collectively, these results suggest that the developed test provides a valid, practical, and game-specific assessment of RHIE ability for rugby league players.

The average RPE at the conclusion of the RHIE test for the First and Second Grade players was 7.3 and 8.4 units, respectively. Based on the verbal anchors for the RPE scale, players described the test as ranging from “very hard” to “very, very hard”. Moreover, the higher RPE in the Second Grade players, despite poorer performances on the RHIE test suggest that the test was more demanding for players with poorer RHIE ability. While heart rate and blood lactate concentration may have been useful to describe the physiological demands of the RHIE test, in the absence of these measures, the RPE results demonstrate the physically demanding nature of RHIE exercise.

Although a wide range of physical qualities were tested, very few of these qualities were associated with RHIE ability. However, we found large associations (r = ≥0.75)
between acceleration qualities and the average speed, and maximum repetition body-mass dips and total 2D Player Load™ performed over the course of the test. Moreover, players with better developed acceleration demonstrated smaller percentage decrements in speed, while players with greater maximum repetition body-mass dips showed smaller percentage decrements in 2D Player Load™. Collectively, these results suggest that well-developed acceleration and upper-body muscular endurance qualities permit a greater overall RHIE performance, but may not protect against reductions in sprinting and tackling performance when the RHIE demands are high. From a practical perspective, the development of acceleration qualities, as well as upper-body muscular endurance may contribute to high total RHIE performance in rugby league players, but other physical qualities may prevent reductions in RHIE ability.

A novel approach employed in this study was the use of accelerometers to quantify the load associated with physical collisions. The percentage decrement in 2D Player Load™ (-17.5%) was considerably greater than the percentage decrement in speed (-3.5%). These finding highlight the physically demanding nature of repeated tackling, but also emphasise that relying solely on repeated-sprint results may provide a false indication of the fatiguing effects of tackles. Given the importance of developing large impact forces in tackles in order to “win” the tackle contest, any fatigue-induced reductions in tackling ability may compromise RHIE ability and ultimately team performance. Based on the results of this study, we recommend the use of accelerometers to quantify the non-running (i.e. physical contact) components of team sport activities in both physical performance tests and match-play. Using this approach, sport scientists and strength and conditioning coaches can determine whether RHIE ability is limited by either repeated-sprint performance, repeated-tackling performance or a combination of both.
Practical Applications

There are several practical applications from this study that are relevant to the applied sport scientist and strength and conditioning coach. Firstly, given the poor relationship between repeated-sprint ability and RHIE ability,\(^7\) it is likely that isolated running programs will result in players being underprepared for the RHIE demands of rugby league match-play. Based on its discriminatory ability, we recommend the use of the RHIE test to assess the preparedness of rugby league players for the most extreme demands of match-play. Secondly, the repeated sprinting and tackling that occurs during RHIE bouts results in significant decrements in both speed and 2D Player Load\(^{TM}\), although the decrement in 2D Player Load\(^{TM}\) is considerably greater than the decrement in speed. The use of a game-specific RHIE test provides insight into the physical quality (i.e. either speed or tackling ability) that is most compromised by the fatigue associated with RHIE exercise. Thirdly, while no other physical quality discriminated between the higher and lower-skilled rugby league players of this study, large associations were found between acceleration and upper-body muscular endurance qualities and performance on the RHIE test. The development of acceleration and upper-body muscular endurance will likely transfer to improved RHIE ability. Finally, given the game-specific and demanding nature of the RHIE test, strength and conditioning coaches could use the test as supplementary training, or modify components of the test to perform as a training drill to develop RHIE ability.

Conclusions

In conclusion, this study investigated the relationship between RHIE ability and speed, aerobic power, upper and lower body strength, and endurance in rugby league players. Our results demonstrate large positive associations between acceleration qualities and average speed (\(r = 0.75\)) and upper-body muscular endurance and total 2D Player Load\(^{TM}\) (\(r = 0.76\)) over the course of the test. These findings demonstrate that the ability to maintain high
speed and 2D Player Load™ is associated with well-developed acceleration and upper-body muscular endurance qualities.
References


Predictors of Repeated High-Intensity Effort Ability in Rugby League Players” by Gabbett TJ, Wheeler AJ

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**Figure 1.** Schematic representation of the repeated high-intensity effort test.

Players start the test at point “A”, performing a maximal 10 m sprint, followed by a 5 m deceleration to point “B” (performed in 6 s). Players then complete 3 full-contact 1-on-1 tackle efforts, with each tackle performed on a 6 s cycle. After completing the 3 tackle efforts, (C) players perform a 30 m active (jog) recovery (performed in ~13 s) back to the start. Players are provided a 3 s count-down before performing the next repetition. Players complete 4 repetitions of the test, with each repetition performed on a 40 s cycle.
Figure 2. Rating of perceived exertion after each repetition of the repeated high-intensity effort test, for First Grade and Second Grade players. * Denotes a moderate difference (effect size = 0.61-1.2) between groups.
### Table 1. Physical qualities of First Grade and Second Grade rugby league players.

<table>
<thead>
<tr>
<th></th>
<th>First Grade</th>
<th>Second Grade</th>
<th>Effect Size</th>
</tr>
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<tbody>
<tr>
<td><strong>Upper-Body Muscular Strength</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4RM Bench Press (kg)</td>
<td>126.4 ± 14.9</td>
<td>129.0 ± 20.1</td>
<td>0.15</td>
</tr>
<tr>
<td>4RM Chin-Up (kg)</td>
<td>25.1 ± 13.4</td>
<td>26.7 ± 11.6</td>
<td>0.13</td>
</tr>
<tr>
<td>4RM Dips (kg)</td>
<td>37.9 ± 9.1</td>
<td>43.0 ± 12.6</td>
<td>0.46</td>
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<tr>
<td><strong>Upper-Body Muscular Endurance</strong></td>
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<td></td>
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<tr>
<td>Maximum Repetition Chin-Up (no.)</td>
<td>14.2 ± 10.4</td>
<td>17.7 ± 3.8</td>
<td>0.45</td>
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<tr>
<td>Maximum Repetition Dips (no.)</td>
<td>26.8 ± 13.4</td>
<td>26.8 ± 7.5</td>
<td>0.00</td>
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<tr>
<td><strong>Lower-Body Muscular Strength</strong></td>
<td></td>
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<tr>
<td>4RM Squat (kg)</td>
<td>162.0 ± 17.9</td>
<td>184.0 ± 29.7</td>
<td>0.90</td>
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<tr>
<td><strong>Maximal Aerobic Power</strong></td>
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<td></td>
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<tr>
<td>Estimated (\dot{V}O_2) max (ml.kg(^{-1}).min(^{-1}))</td>
<td>51.9 ± 3.3</td>
<td>51.1 ± 4.5</td>
<td>0.20</td>
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<tr>
<td><strong>Repeated High-Intensity Effort Ability</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>First Sprint (m.s(^{-1}))</td>
<td>3.85 ± 0.07</td>
<td>3.90 ± 0.20</td>
<td>0.60</td>
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<tr>
<td>Average Speed (m.s(^{-1}))</td>
<td>3.80 ± 0.08</td>
<td>3.80 ± 0.09</td>
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<td>Speed Decrement (%)</td>
<td>-2.36 ± 1.03*</td>
<td>-4.70 ± 2.05</td>
<td>1.63</td>
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<tr>
<td>Total 2D Player Load(^{TM}) (au)</td>
<td>20.8 ± 4.9</td>
<td>25.9 ± 5.0</td>
<td>1.03</td>
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<tr>
<td>2D Player Load(^{TM}) Decrement (%)</td>
<td>-20.6 ± 8.7</td>
<td>-14.4 ± 10.9</td>
<td>0.62</td>
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Data are mean ± SD. * Significantly different (P<0.05) from Second Grade players. \(\dot{V}O_2\) max = maximal aerobic power. Effect sizes of <0.2, 0.2-0.6, 0.61-1.2, 1.21-2.0, and >2.0 were considered trivial, small, moderate, large, and very large, respectively. RM = repetition maximum; au = arbitrary units.
Table 2. Relationship among selected physical qualities and repeated high-intensity effort ability in semi-professional rugby league players.

<table>
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<th>RHIE&lt;sub&gt;First&lt;/sub&gt;</th>
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<tr>
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<td>2DPL&lt;sub&gt;Tot&lt;/sub&gt;</td>
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<td>0.06</td>
<td>-0.36</td>
<td>1.00</td>
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<tr>
<td>2DPL&lt;sub&gt;Dec&lt;/sub&gt;</td>
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<td>0.22</td>
<td>-0.30</td>
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<tr>
<td>Bench&lt;sub&gt;4RM&lt;/sub&gt;</td>
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<tr>
<td>Chins&lt;sub&gt;4RM&lt;/sub&gt;</td>
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<td>0.57</td>
<td>0.37</td>
<td>0.57</td>
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<tr>
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<td>-0.09</td>
<td>0.09</td>
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<td>-0.08</td>
<td>1.00</td>
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<tr>
<td>Squat&lt;sub&gt;4RM&lt;/sub&gt;</td>
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<td>0.44</td>
<td>-0.38</td>
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<td>Chins&lt;sub&gt;Max&lt;/sub&gt;</td>
<td>0.16</td>
<td>0.32</td>
<td>0.16</td>
<td>0.59</td>
<td>-0.29</td>
<td>-0.04</td>
<td>0.80*</td>
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<td>-0.34</td>
<td>0.02</td>
<td>0.76*</td>
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<td>0.12</td>
<td>0.16</td>
<td>-0.01</td>
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<td>0.62</td>
<td>0.19</td>
<td>0.16</td>
<td>0.39</td>
<td>0.24</td>
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Data are reported as Pearson product moment correlation coefficients, r, and represent pooled data from First Grade and Second Grade players. * Denotes significance at P<0.05. RHIE<sub>First</sub> = speed during the first 10 m sprint of the repeated high-intensity effort test; RHIE<sub>AvgSpd</sub> = average speed across all sprints of the repeated high-intensity effort test; RHIE<sub>SpdDec</sub> = percentage speed decrement across the repeated high-intensity effort test, 2DPL<sub>Tot</sub> = total 2D player load across the repeated high-intensity effort test; 2DPL<sub>Dec</sub> = percentage decrement in 2D player load across the repeated high-intensity effort test; Bench<sub>4RM</sub> = 4RM bench press; Chins<sub>4RM</sub> = 4RM chin-up; Dips<sub>4RM</sub> = 4RM dips; Squat<sub>4RM</sub> = 4RM squat; Chins<sub>Max</sub> = maximum repetition chin-ups with body mass as resistance; Dips<sub>Max</sub> = maximum repetition dips with body mass as resistance; VO<sub>2max</sub> = maximal aerobic power.