Note. This article will be published in a forthcoming issue of the *International Journal of Sports Physiology and Performance*. The article appears here in its accepted, peer-reviewed form, as it was provided by the submitting author. It has not been copyedited, proofread, or formatted by the publisher.

**Section:** Original Investigation

**Article Title:** Repeated High-Intensity Effort Activity in Elite and Semi-Elite Rugby League Match-Play

**Authors:** Georgia M. Black¹ and Tim J. Gabbett¹,²

**Affiliations:** ¹School of Exercise Science, Australian Catholic University, Brisbane, Australia. ²School of Human Movement Studies, The University of Queensland, Brisbane, Australia.

**Journal:** *International Journal of Sports Physiology and Performance*

**Acceptance Date:** July 7, 2014

©2014 Human Kinetics, Inc.

**DOI:** [http://dx.doi.org/10.1123/ijspp.2014-0081](http://dx.doi.org/10.1123/ijspp.2014-0081)
Repeated high-intensity effort activity in elite and semi-elite rugby league match-play

Georgia M. Black¹ and Tim J. Gabbett¹²

¹School of Exercise Science, Australian Catholic University, Brisbane, Australia

²School of Human Movement Studies, The University of Queensland, Brisbane, Australia

Address correspondence to:
Dr. Tim J. Gabbett
School of Exercise Science,
Australian Catholic University,
Brisbane, AUSTRALIA 4014
Email: tim_gabbett@yahoo.com.au

Submission Type: Original Investigation
Abstract Word Count: 248 Words
Text-Only Word Count: 2960 Words
Number of Figures and Tables: 2 Tables, 3 Figures
Abstract

**Purpose:** No study has investigated the frequency and nature of repeated high-intensity effort (RHIE) bouts across elite and semi-elite rugby league competitions. This study examined RHIE activity in rugby league match-play across playing standards. **Methods:** Thirty-six elite and sixty-four semi-elite rugby league players participated in this study. Global positioning system analysis was completed during 17 elite and 14 semi-elite matches. **Results:** The most commonly occurring RHIE bouts involved two efforts (2-RHIE) for both elite and semi-elite players. Only small differences were found in 2-RHIE activity between elite and semi-elite match-play (Effect Size [ES] ≥0.31 ± 0.15, ≥88%, likely). RHIE bouts were more likely to involve contact as the number of efforts in a bout increased (ES ≥0.40 ± 0.15, 100%, almost certainly). Semi-elite players performed a greater proportion of 2 contact effort RHIE bouts compared to their elite counterparts (68.2 % vs. 60.6%, ES 0.33 ± 0.15, 92%, likely), while elite players performed a greater proportion of 3-effort bouts (26.9% vs. 21.1%, ES 0.31 ± 0.15, 88%, likely). Elite players also had a shorter recovery (1.00-3.99 min vs. ≥4.00 min) between RHIE bouts (ES ≥1.60 ± 0.71, ≥94%, likely). **Conclusion:** These findings highlight the RHIE demands of elite and semi-elite rugby league match-play. Elite players are more likely to perform RHIE bouts consisting of 3 efforts, and are also more likely to have a shorter recovery time between bouts. Exposing players to these RHIE demands in training is likely to improve their ability to tolerate the most demanding passages of match-play.

**Keywords:** team sports, global positioning system, match analysis, collision sport
Introduction

The importance of repeated sprint ability to team sport performance has been well documented.1 However, in some teams sports (e.g. rugby league, rugby union, and Australian football), these sprints often include tackling and physical collisions.2-4 Despite the importance of tackling and physical contact to success in collision sports, research into the high-intensity exercise demands, particularly in rugby league, was originally confined to the assessment of high-intensity running and repeated-sprint ability.5 Recently, research has incorporated tackling and physical collisions into repeated-sprint definitions, and defined these high-intensity activities as a repeated high-intensity effort (RHIE) bout.2,4 A study of elite National Rugby League (NRL) match-play showed that repeated sprint bouts occurred infrequently during competition, with players performing on average, 1 repeated sprint bout per game.2 Conversely, 3-RHIE bouts (defined as 3 or more maximal acceleration, high speed, or contact efforts) occurred regularly during match-play, with players performing, on average, 9 bouts per game.2 These results suggest that the development of RHIE ability is critical for rugby league players.

Time-motion analysis studies have shown that elite soccer players typically perform more high-intensity running than semi-elite competitors.6 The number of repeated-sprint and repeated-effort bouts performed has also been reported to be a significant discriminator of elite and semi-elite team sport competition.7,8 Female soccer players perform more repeated-sprint bouts in international matches than national and domestic matches.7 It was also demonstrated that during international matches the average number of sprints were greater and the recovery between sprints was shorter.7 In rugby league, the 3-RHIE demands are higher during senior elite than junior elite match-play.8 Gabbett8 reported that NRL players performed significantly more 3-RHIE bouts (13.0 ± 0.8 bouts) than players from the National
Youth Competition (9.7 ± 1.1 bouts). Collectively, these studies demonstrate that repeated-sprint and RHIE bout frequency differ across playing standards.

Research suggests that repeated sprint bouts are often critical to the outcome of hockey matches.1 Furthermore, 3-RHIE bouts occur in close proximity to a team’s own try-line and the opposition’s try-line,9 with the majority (approximately 70%) of rugby league tries scored or conceded in close proximity to a 3-RHIE bout.4 These studies suggest that the ability or inability to perform these activities could prove vital to the match outcome.4,9

Although 3-RHIE ability appears to be a critical determinant to the outcome of a match10 and provides information on the most demanding passages of play, the current definition of 3 efforts eliminates successive, short recovery efforts that may also be physically demanding but fail to meet the repeated-effort criteria.11 Two consecutive high intensity efforts (i.e. 2-RHIE) are also common during team sports.11,12 When rest periods between high-intensity actions are below 30 s in duration, subsequent sprint performance can deteriorate due to decreases in adenosine triphosphate concentration and intramuscular pH slowing phosphocreatine resynthesis.13 Therefore, an understanding of the frequency of two consecutive efforts may provide insight to coaches and offer evidence to support conditioning programs to adequately prepare players for the 2-RHIE demands of competition.

In general, previous studies that have provided information on repeated-sprint and RHIE activities in team sports have reported the average exercise to rest ratios across an entire match, rather than the most intense periods of play.5 However, recently Carling et al12 reported the highest number of efforts performed in a RHIE bout during elite soccer match-play. The peak number of individual high-intensity actions reported within any single bout of repeated high-intensity activity was seven.12 Austin et al4 were the first to examine the frequency and duration of RHIE activity in rugby league to determine the most demanding passages of play likely to be experienced during a match. The number of bouts involving 3 or
more efforts (i.e. 3-RHIE bouts) for the hit-up forwards, adjustables, and outside backs positional groups ranged from 9-17, 2-8, and 3-7, respectively. This data was the first to demonstrate that the nature of 3-RHIE bouts was specific to playing position. Austin et al also reported that the highest number of efforts in a 3-RHIE bout during a rugby league match was 20, performed by a hit-up forward, and lasting 64 seconds. However, there has been no study in rugby league to compare the RHIE demands of elite and semi-elite competitions. With this in mind, the purpose of this study was to compare the nature and frequency of ≥2-RHIE activity between elite (i.e. NRL) and semi-elite (i.e. Queensland Cup) competitions.

**Methods**

**Subjects**

Two teams competing in the NRL (elite) competition, as well as four teams competing in the Queensland Cup (semi-elite) rugby league competition were invited to participate in a study of the RHIE activities performed during elite and semi-elite rugby league match-play. The semi-elite Queensland Cup competition is a feeder competition to the elite NRL competition, with players from this level striving to gain selection in an elite NRL team. Players from the Queensland Cup can be called upon to play in the NRL competition if injuries occur or their form warrants selection. The final sample included 36 elite (mean ± SD age, 24.7 ± 3.4 yr) and 64 semi-elite (mean ± SD age, 24.1 ± 3.1 yr) rugby league players. 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.
“Repeated High-Intensity Effort Activity in Elite and Semi-Elite Rugby League Match-Play” by Black GM, Gabbett TJ
*International Journal of Sports Physiology and Performance*
© 2014 Human Kinetics, Inc.

**Design**

This study investigated the RHIE demands of elite and semi-elite rugby league players using a prospective cohort observational design over one competitive season. The RHIE demands of elite and semi-elite rugby league players were compared by separating players into four positional groups representing hit-up forwards (props), wide-running forwards (second rowers and locks), adjustables (hookers, halfbacks, five-eighths, and fullbacks) and outside backs (centres and wingers).\(^2\) Thirty-six elite players (n=8 hit-up forwards; n=9 wide running forwards; n=10 adjustables; and n=9 outside backs) and 64 semi-elite players (n=12 hit-up forwards; n=14 wide running forwards; n=20 adjustables; and n=18 outside backs) were analysed. Repeated high-intensity effort bouts were separated into contact or non-contact bouts and further divided into 2-effort (2-RHIE), 3-effort (3-RHIE) and ≥4-effort (4-RHIE) bouts. Our dependent variables included the frequency and nature of 2-RHIE, 3-RHIE, and 4-RHIE bouts, along with the recovery between bouts, while our independent variables included playing level (i.e. elite or semi-elite) and phase of match (i.e. first or second half).

**Global Positioning System Analysis**

Global positioning system (GPS) analysis was completed during 17 NRL matches (totalling 122 individual files) and 14 Queensland Cup matches (totalling 135 individual files). Movement was recorded using a minimaxX GPS unit (Catapult Innovations, Melbourne, Australia) sampling at 10 Hz. The GPS signal provided information on speed, distance, position, and via its tri-axial accelerometer and gyroscope (sampling at 100 Hz), the unit recorded data on physical collisions and RHIE bouts. The unit was worn in a small vest, on the upper back of the players.
Repeated High-Intensity Effort (RHIE) Activity

The definition of a RHIE bout used by Gabbett et al.\textsuperscript{14} was modified for this study to allow the physically demanding activities of two efforts to also be reported. A 2-RHIE bout was defined as 2 high acceleration (≥2.79 m.s\textsuperscript{-2}),\textsuperscript{15} high speed (≥5 m.s\textsuperscript{-1}), or contact efforts with less than 21 seconds recovery between efforts. The 10 Hz minimaxX units have been shown to have good reliability and accuracy for measuring acceleration and sprint efforts commonly performed by team sport athletes\textsuperscript{16} and valid measurements of tackles\textsuperscript{17} and RHIE bouts\textsuperscript{8} commonly observed in collision sports. For a tackle to be detected, the unit was required to be in a non-vertical position, meaning the player was leaning forwards, backwards, or to the left or right. Instantaneous player load was calculated from the sum of the three axes of acceleration. A spike in instantaneous player load\textsuperscript{17} shortly before the change in orientation of the unit was also required for the collision to be detected.\textsuperscript{18}

Statistical Analysis

Based upon the fact that the p-value and traditional null-hypothesis statistics do not provide information on the size and direction of the effect and can represent an effect that is practically irrelevant,\textsuperscript{19} non-hypothesis testing was used. We chose magnitude-based inferential statistics (including effect sizes, confidence limits, and likelihoods) to provide information on the size of the differences allowing a more practical and meaningful explanation of the results. Differences in the number of 2-RHIE, 3-RHIE, and ≥4-RHIE bouts performed per match and recovery between bouts (calculated as the elapsed time between the completion of one RHIE bout and the commencement of a subsequent RHIE bout) between elite and semi-elite players and first and second halves were analysed using Cohen’s effect size (ES) statistic\textsuperscript{20} and 90% confidence limits (CL). 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.\textsuperscript{19} Magnitudes of differences between the two groups were classified as
substantially greater or lesser when there was a $\geq 75\%$ likelihood of the effect being equal to or greater than the smallest worthwhile change estimated as 0.2 x between-subject standard deviation (small ES). Effects with less certainty were classified as trivial and where the ± 90% confidence interval (CI) of the ES crossed the boundaries of ES −0.2 and 0.2, the effect was reported as unclear. A criterion of 0.2 to represent a small ES, equated to the performance of an additional 2-RHIE bout per player per match, and an additional effort for each 2-RHIE bout performed. The percentage of 2-RHIE, 3-RHIE, and $\geq 4$RHIE bouts, along with the percentage of different recovery durations between bouts, were calculated for each player. Based on these individual percentages, the overall means and SDs were then calculated.

**Results**

*Most Demanding RHIE Bout between Competitions and across Halves*

The most demanding passage of play for elite players in the first half included a RHIE bout consisting of 10 efforts performed by an adjustable. The duration of the bout was 93 s and included 5 tackles and 5 acceleration efforts. The average effort duration was 2.1 s and maximum effort duration was 6.8 s. The average recovery between efforts was 4.5 s and the maximum effort recovery was 12.9 s. In the second half, we recorded a RHIE bout that consisted of 13 efforts performed by a hit-up forward. The duration of the bout was 120 s and included 4 tackles and 9 acceleration efforts. The average effort duration was 2.3 s and maximum effort duration was 5 s. The average recovery between efforts was 5 s and the maximum effort recovery was 18 s (Figure 1).

The most demanding passage of play for semi-elite players in the first half included a RHIE bout consisting of 8 efforts performed by a wide-running forward. The average effort duration during this bout was 2.1 s and the maximum effort duration was 3.6 s. The duration of the bout was 62 s and included 8 sprints and acceleration efforts. The average recovery
time between efforts was 7 s and the maximum recovery time was 20.7 s. In the second half, the most demanding RHIE bout consisted of 7 efforts performed by a hit-up forward. The duration of the bout was 45 s and included 2 tackles and 5 acceleration efforts. The average effort duration was 1.0 s and maximum effort duration was 1.8 s. The average recovery between efforts was 2 s and the maximum effort recovery was 6.2 s.

**Positional Differences**

During elite competition, adjustables performed one 2-RHIE bout every 7.0 ± 9.3 min, outside backs performed 1 2-RHIE bout every 4.9 ± 2.6 min, wide-running forwards performed 1 2-RHIE bout every 6.1 ± 4.8 min and hit-up forwards performed 1 2-RHIE bout every 7.3 ± 5.6 min. Semi-elite adjustables performed one 2-RHIE bout every 7.9 ± 5.9 min, outside backs performed 1 2-RHIE bout every 7.5 ± 4.1 min, wide-running forwards performed 1 2-RHIE bout every 6.5 ± 4.2 min and hit-up forwards performed 1 2-RHIE bout every 5.2 ± 2.9 min. There were no meaningful differences in RHIE frequency between the first and second half for any positional group in either elite or semi-elite players (Table 1). Elite outside backs were likely to perform additional 2-RHIE bouts during a match compared to their semi-elite counterparts (ES 0.54 ± 0.28, 98%, very likely). Elite hit-up forwards were also more likely to perform 2-RHIE bouts compared to semi-elite hit-up forwards (ES 0.36 ± 0.33, 78%, likely).

**Contact and Non-Contact RHIE Bouts**

The proportion of non-contact RHIE bouts involving 2-efforts was greater (100%, almost certainly) than the RHIE bouts involving 2 contact efforts for both elite (ES 0.57 ± 0.15) and semi-elite (ES 0.44 ± 0.15) players. For both elite and semi-elite players, RHIE bouts were more likely to involve contact as the number of efforts in a bout increased (ES ≥0.40 ± 0.15, 99%, almost certainly) (Figure 2).
Only small differences were found in RHIE activity between elite and semi-elite match-play. Semi-elite players performed a likely greater proportion of 2 contact effort RHIE bouts compared to their elite counterparts (ES 0.33 ± 0.15, 92%, likely), while elite players performed a likely greater proportion of 3-effort bouts (ES 0.31 ± 0.15, 88%, likely). There were likely no meaningful differences between elite and semi-elite players for the proportion of ≥4-effort RHIE bouts (ES 0.12 ± 0.15, 20%, unlikely). Elite players performed a greater proportion of RHIE bouts involving 2 contact efforts (ES 0.30 ± 0.21, 77%, likely), and a smaller proportion of RHIE bouts involving ≥4 contact efforts (ES -0.29 ± 0.23, 76%, likely) in the second half of matches (Table 2). No other meaningful differences in the proportion of contact and non-contact RHIE bouts were found between the first and second half for elite or semi-elite players.

Recovery between RHIE Bouts

The recovery between 2-RHIE bouts was almost certainly lower for elite than semi-elite players. Elite players almost certainly performed a greater proportion of 2-RHIE bouts with 1-1.99 min (ES 1.74 ± 0.28, 99%, almost certainly), 2-2.99 min (ES 1.69 ± 0.59, 98%, very likely), and 3-3.99 min (ES 1.60 ± 0.71, 94%, likely) recovery between bouts than semi-elite players (Figure 3). The recovery between 2-RHIE bouts remained relatively constant over the first and second half for both competitions. Elite players performed a 2-RHIE bout every 6.3 ± 4.4 and 6.2 ± 5.4 minutes in the first and second half, respectively. Semi-elite players performed a 2-RHIE bout every 6.7 ± 4.4 and 7.2 ± 5.9 minutes in the first and second half, respectively.

Discussion

The results of this study demonstrate small differences in the proportion of contact and non-contact RHIE bouts between elite and semi-elite players. Semi-elite players were more likely to perform 2-efforts in a RHIE bout, while elite players were more likely to
perform RHIE bouts consisting of 3-efforts. Furthermore, this study highlights the most demanding passages of play for both competitions and different positional groups. Although ≥4-RHIE bouts occur infrequently during competition, exposing players to these demands is likely to improve their ability to perform and tolerate the most demanding, as well as the least demanding (i.e. 2-RHIE bouts) passages of play. These findings suggest that rugby league RHIE training should include the most demanding passages of play in order to adequately prepare players for the demands of competition.

Elite and semi-elite players were more likely to perform 2-effort bouts than any other number of efforts. Given this, players from both competitions are likely to benefit from performing consecutive high-intensity running efforts in training. However, elite (39.4% vs. 25.3%) and semi-elite (31.8% vs. 21.3%) players were involved in more contact RHIE bouts that involved ≥3-efforts compared to non-contact bouts suggesting that as the number of efforts in a bout increases, so does the likelihood of performing a contact effort. This finding reinforces the importance of including contact conditioning when training RHIE ability. Small, but practically meaningful differences were found between semi-elite (68.2%) and elite (60.2%) players for the proportion of 2-RHIE bouts. However, elite players were more likely to be involved in bouts consisting of 3 efforts (26.8% vs. 21.1%). These findings are consistent with previous rugby league\textsuperscript{8} and soccer\textsuperscript{7} studies that have shown that a higher competitive level increases the playing intensity and requires a greater number of repeated high-intensity efforts to be performed. Also, anecdotal evidence from coaches has shown that elite rugby league players become less effective, with reductions in tackling proficiency reported, after performing 3 tackles in a row,\textsuperscript{8} suggesting that semi-elite players’ tackling proficiency may decrease after 2 tackles.

Elite players were more likely to have recovery durations between 2-RHIE bouts ranging from 1-4 minutes, while semi-elite players were more likely to have recovery
durations between 2-RHIE bouts ranging from 5-7 minutes. This finding suggests that not only are elite players more likely to perform RHIE bouts consisting of 3 efforts, they are also more likely to have a shorter recovery time between bouts, demonstrating the demanding frequency of which elite players are required to perform RHIE bouts. Although there were meaningful differences in 2-RHIE recovery periods between elite and semi-elite players, the average recovery time between efforts (3.77-4.82 s) during a bout were similar across halves. Research has shown that recovery between sprints increases in the second half of soccer matches, potentially because players employ a pacing strategy in an attempt to preserve repeated-sprint performance. The present findings suggest that the recovery between efforts in a 2-RHIE bout remains relatively stable over the course of a match in elite and semi-elite rugby league players. However, elite players performed a greater proportion of contact RHIE bouts involving 2 efforts (57.1% vs. 63.9%), and a smaller proportion of contact RHIE bouts involving ≥4 efforts (15.0% vs. 10.3%) in the second half of matches. These findings suggest that in elite rugby league match-play (1) tactical strategies are employed to ensure players perform a greater number of RHIE bouts involving 4 or more efforts, (2) players employ an “all-out” pacing strategy, in the knowledge that they can be interchanged or ‘down-regulate’ exercise intensity as the match progresses, or (3) the fatigue associated with performing contact RHIE bouts reduces the number of contact efforts that can be performed within a bout.

The positional differences identified are in contrast to others, who have reported that hit-up forwards performed the greatest frequency, and outside backs the lowest frequency of 2-RHIE bouts per game. Given that we also reported RHIE bouts that included 2-efforts, this finding could suggest that outside backs are involved in a higher number of 2-effort RHIE bouts compared to hit-up forwards. Elite outside backs performed 2-RHIE bouts more frequently than semi-elite players, demonstrating the lower intensity of semi-elite rugby
league match-play, particularly for outside backs. This finding suggests that semi-elite outside backs may be underprepared to perform 2-RHIE bouts during elite matches. Therefore, to allow for transition into the elite competition, semi-elite outside backs should be exposed to the 2-RHIE demands of elite players in training. Given the differences in the frequency of 2-RHIE bouts between playing positions, these findings also suggest that RHIE training should be specific to each position. In addition, at least some of the training time devoted to developing RHIE ability should reflect the most demanding passages of play expected during competition.

That the most intense RHIE bout performed during an elite match consisted of 13 efforts by a hit-up forward, and lasted for 120 seconds, reinforces the importance of including tackling and collisions as a high-intensity effort, as sprinting activities alone are likely to result in players being underprepared for the most demanding passages of play. The most demanding passage of play for semi-elite players included a RHIE bout lasting 62 seconds and highlights a marked difference in the most demanding RHIE scenarios of elite and semi-elite match-play. For semi-elite players to be prepared for elite rugby league match-play, it is likely they would benefit from exposure to the worst case scenario experienced in elite competition.

**Practical Applications**

Given the high frequency of two consecutive high-intensity efforts performed during a match, rugby league players are likely to benefit from performing two consecutive high-intensity efforts at training. Elite players are also more likely to perform more efforts in a bout. Training should be developed to replicate these demands. Based on the differences in 2-RHIE and 3-RHIE demands between competitions and playing positions, training programs should be individualised to resemble the demands of match-play for the different positional groups. Players should also be exposed to short recovery periods between bouts to adequately
prepare them for matches. Finally, the present data can be used to develop training programs to replicate the worst case scenario expected during competition, by exposing players to the maximum number of efforts and minimal recovery periods that they are likely to encounter during a match.

**Conclusion**

We found that semi-elite players were more likely to perform 2-efforts in a RHIE bout, while elite players were more likely to perform 3-efforts in a RHIE bout. A novel finding of this study was that for both elite and semi-elite players, RHIE bouts were more likely to involve contact as the number of efforts in a bout increased. Furthermore, it was established that not only are elite players more likely to perform RHIE bouts consisting of 3-efforts, they are also more likely to have a shorter recovery time between bouts. The positional differences across competitions were also highlighted, with results suggesting that RHIE training should be individualised for the different positional groups. It also appears important to expose players to the >4-effort RHIE bouts to adequately prepare them for the most demanding passages of play. Given the differences in the most demanding RHIE scenarios across competitions, for semi-elite players to be prepared for elite rugby league match-play, it is likely they would benefit from exposure to the worst case scenario experienced in elite competition.
References


Figure 1. Frequency of repeated high-intensity effort bouts during elite and semi-elite rugby league match-play. “a” signifies the most demanding repeated high-intensity effort bout for the first half. “b” signifies the most demanding repeated high-intensity effort bout for the second half. RHIE = repeated high-intensity effort. Data reported as percentages.
Figure 2. Proportion of contact and non-contact repeated high-intensity effort bouts for elite and semi-elite players. * denotes a ≥75% likelihood of the effect being equal or greater than smallest worthwhile differences between contact and non-contact bouts. RHIE = repeated high-intensity effort. Data reported as percentages.
Figure 3. Recovery between repeated high-intensity effort bouts during elite and semi-elite rugby league match-play. * denotes a ≥75% likelihood of the effect being equal or greater than the smallest worthwhile difference between elite and semi-elite players. RHIE = repeated high-intensity effort. Data reported as percentage ± SD.
Table 1. Frequency of repeated high-intensity effort bouts in the first and second half of elite and semi-elite rugby league match-play for the hit-up forwards, wide-running forwards, adjustables, and outside backs.

<table>
<thead>
<tr>
<th></th>
<th>First Half</th>
<th>Second Half</th>
<th>ES ± CL</th>
<th>Likelihood, Descriptor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Elite</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hit-Up Forwards</td>
<td>1 every 7.8 ± 6.3 min</td>
<td>1 every 6.9 ± 5.1 min</td>
<td>-0.15 ± 0.48</td>
<td>43%, possibly</td>
</tr>
<tr>
<td>Wide-Running Forwards</td>
<td>1 every 5.5 ± 3.8 min</td>
<td>1 every 6.7 ± 5.6 min</td>
<td>0.24 ± 0.39</td>
<td>56%, possibly</td>
</tr>
<tr>
<td>Adjustables</td>
<td>1 every 8.0 ± 11.6 min</td>
<td>1 every 6.2 ± 7.3 min</td>
<td>-0.18 ± 0.49</td>
<td>48%, possibly</td>
</tr>
<tr>
<td>Outside Backs</td>
<td>1 every 4.7 ± 2.5 min</td>
<td>1 every 5.0 ± 2.8 min</td>
<td>0.08 ± 0.49</td>
<td>34%, possibly</td>
</tr>
<tr>
<td><strong>Semi-Elite</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hit-Up Forwards</td>
<td>1 every 5.1 ± 2.1 min</td>
<td>1 every 5.3 ± 3.6 min</td>
<td>-0.17 ± 0.60</td>
<td>47%, possibly</td>
</tr>
<tr>
<td>Wide-Running Forwards</td>
<td>1 every 6.6 ± 4.8 min</td>
<td>1 every 6.7 ± 3.6 min</td>
<td>0.05 ± 0.31</td>
<td>27%, possibly</td>
</tr>
<tr>
<td>Adjustables</td>
<td>1 every 7.7 ± 6.6 min</td>
<td>1 every 8.1 ± 6.3 min</td>
<td>0.06 ± 0.38</td>
<td>27%, possibly</td>
</tr>
<tr>
<td>Outside Backs</td>
<td>1 every 6.6 ± 2.8 min</td>
<td>1 every 8.4 ± 7.8 min</td>
<td>0.31 ± 0.44</td>
<td>67%, possibly</td>
</tr>
</tbody>
</table>

RHIE = repeated high-intensity effort; ES = effect size; CL = 90% confidence limit. Data are reported as means ± SD.
Table 2. Proportion of repeated high-intensity effort bouts involving two, three, and 4 or more efforts in the first and second half of elite and semi-elite rugby league match-play.

<table>
<thead>
<tr>
<th></th>
<th>Elite</th>
<th></th>
<th>Semi-Elite</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First Half</td>
<td>Second Half</td>
<td>ES ± CL</td>
<td>Likelihood, Descriptor</td>
</tr>
<tr>
<td><strong>Contact</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-RHIE</td>
<td>57.1 ± 22.9%</td>
<td>63.9 ± 22.8%</td>
<td>0.30 ± 0.21</td>
<td>77%, likely</td>
</tr>
<tr>
<td>3-RHIE</td>
<td>28.0 ± 19.6%</td>
<td>25.8 ± 19.6%</td>
<td>-0.11 ± 0.21</td>
<td>25%, unlikely</td>
</tr>
<tr>
<td>≥4-RHIE</td>
<td>15.0 ± 17.3%</td>
<td>10.3 ± 14.4%</td>
<td>-0.29 ± 0.23</td>
<td>76%, likely</td>
</tr>
<tr>
<td><strong>Non-Contact</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-RHIE</td>
<td>73.7 ± 22.1%</td>
<td>75.0 ± 24.8%</td>
<td>0.05 ± 0.23</td>
<td>14%, unlikely</td>
</tr>
<tr>
<td>3-RHIE</td>
<td>18.0 ± 18.3%</td>
<td>19.7 ± 20.5%</td>
<td>0.09 ± 0.23</td>
<td>21%, unlikely</td>
</tr>
<tr>
<td>≥4-RHIE</td>
<td>7.2 ± 11.1%</td>
<td>5.7 ± 12.5%</td>
<td>-0.13 ± 0.23</td>
<td>30%, possibly</td>
</tr>
</tbody>
</table>

2-RHIE = repeated high-intensity effort bout involving 2-efforts; 3-RHIE = repeated high-intensity effort bout involving 3-efforts; ≥4-RHIE = repeated high-intensity effort bout involving 4 or more efforts. ES = effect size; CL = 90% confidence limit. Data are reported as means ± SD.