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Article Title: Repeated High-Intensity Effort Activity in Relation to Tries Scored and Conceded during Rugby League Match-Play

Authors: Tim J. Gabbett^{a,b} and Caleb W. Gahan^a

Affiliations: ^aSchool of Exercise Science, Australian Catholic University, Brisbane, Australia. ^bSchool of Human Movement Studies, The University of Queensland, Brisbane, Australia.

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**Repeated High-Intensity Effort Activity in Relation to Tries Scored and Conceded
during Rugby League Match-Play**

Tim J. Gabbett^{a,b} and Caleb W. Gahan^a

^a School of Exercise Science, Australian Catholic University, Brisbane, Australia

^b School 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

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Abstract

Purpose: To examine the nature and frequency of rugby league repeated high-intensity effort (RHIE) activity in relation to tries scored and conceded in successful and unsuccessful teams.

Methods: One-hundred and eighty-five semi-professional rugby league players (mean \pm SD age: 23.7 ± 3.2 yr) from 11 teams participated in this study. Global positioning system (GPS) data was collected during 21 matches. Data were analysed for the total number of RHIE bouts, efforts per bout, duration of efforts and recovery between efforts. Using notational analysis, a RHIE bout frequency distribution, representing 0-60s, 61-120s, 121-180s, 181-240s, and 241-300s prior to scoring and conceding a try was established. **Results:** Over 50% of RHIE bouts occurred within five minutes of a try. Bottom 4 teams performed a greater proportion of bouts within five minutes of a try than Top 4 teams (61.5% vs. 48.2%, effect size, $ES = 0.69 \pm 0.28$, $p=0.0001$). Top 4 teams performed a greater number of RHIE bouts per conceded try (3.0 ± 2.1 vs. 1.6 ± 0.7 , $ES = 0.74 \pm 0.51$, $p<0.05$), while Bottom 4 teams performed a greater number of RHIE bouts per try scored (3.6 ± 2.5 vs. 2.1 ± 1.7 , $ES = 0.70 \pm 0.71$, $p=0.10$). **Conclusion:** The majority of rugby league RHIE bouts occur at critical periods during match-play. Successful rugby league teams perform more RHIE bouts prior to conceding tries, while unsuccessful teams perform more bouts prior to scoring tries. These findings demonstrate that unsuccessful teams are required to work harder to score tries while successful teams work harder to prevent tries.

Keywords: contact, conditioning, football, activity profiles, team sport, GPS

Introduction

Rugby League is an intermittent team sport consisting of high-intensity efforts such as sprinting, tackling and changes of direction, interspersed with periods of lower-intensity activity.¹⁻³ The game consists of two 40 minute periods with a 10 minute half time. A team is allowed 13 players on the field at any one time and each team is allowed 4 substitution players. There is a maximum of 10 interchanges allowed for each team.

Early research into the demands of intermittent team sports has suggested that sprinting and repeated-sprint ability (RSA) are central to performance.⁴⁻⁶ In fact, some researchers have suggested that RSA is a critical determinant to the outcome of a match.^{4,7} Until recently, research into the physical demands of rugby league has been limited to the study of high-intensity running and has not included the assessment of tackling or collisions, and the demand these actions place on players. Gabbett⁸ found that repeated-sprint bouts were uncommon in rugby league match-play, with players performing between 0 and 4 (mean \pm SE: 1 ± 1) bouts per match. However, repeated high-intensity effort (RHIE) bouts, involving sprints and collisions were far more common, occurring up to 25 (mean \pm SE: 9 ± 1) times per match.⁶ Subsequent studies have included RHIE bouts in their assessment of the physical demands of rugby league match-play. Studies have examined the influence of playing standard,³ the opposing team,⁷ phase of play⁸ and field position⁸ on RHIE activity. Several studies have also examined the relationship between physical qualities and match activity profiles, including RHIE bout frequency.^{9,10}

Austin et al.⁵ examined the frequency of RHIE bouts relative to points scored, to determine if RHIE bouts occurred more frequently during critical periods of rugby league match-play. These researchers found that 70% of RHIE bouts occurred within five minutes of a try being scored. While these results have provided some insight into the importance of RHIE activity on key match events, this study was limited to a small sample size; a total of

five matches were analysed, with only 3 players assessed each match. In addition, the authors did not differentiate between bouts which occurred before scoring, or conceding a try. Finally all players were members of the same team, limiting the generalisability to both successful and unsuccessful teams.

With this in mind, the purpose of this study was to examine the nature and frequency of rugby league RHIE bouts and determine if more RHIE bouts occur before scoring or conceding tries. We also examined the difference between successful (Top 4) and unsuccessful (Bottom 4) teams to determine if successful teams performed more RHIE bouts at critical periods during match-play. It was hypothesised that unsuccessful teams would perform more RHIE bouts prior to scoring a try, while successful teams would perform more RHIE bouts prior to conceding a try.

Methods

Subjects

At the beginning of the 2012 rugby league season, the 12 teams competing in the Queensland Cup rugby league competition were invited to participate in a study of the physical demands of semi-professional rugby league. The Queensland Cup is the second best competition in Australia, with players from this competition often selected to play in the elite National Rugby League competition. 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.

Design

This study investigated the RHIE demands of semi-elite rugby league match-play in relation to tries scored and conceded, using a prospective cohort observational design. The

RHIE demands of semi-elite players were compared in 2 ways. First, players were separated into Top 4 and Bottom 4 based on their ladder position at the completion of the season. Second, it was determined whether the RHIE bout occurred prior to conceding or scoring tries. A frequency distribution was developed for all RHIE bouts based on the elapsed time between performing the RHIE bout and scoring or conceding the try. A frequency distribution representing 0-60 s, 61-120 s, 121-180 s, 181-240 s, and 241-300 s prior to scoring and conceding a try was established.

Global Positioning System Analysis

Global positioning system (GPS) data was collected from 185 semi-professional Rugby League players (mean \pm SD age: 23.7 \pm 3.2 yr) from 11 Queensland Cup teams. GPS data was collected during a total of 26 matches. After the season, seven teams were selected based on final ladder position (the Bottom 4 teams and three of the Top 4 teams) for further analysis. A total of 264 data files from 21 matches were analysed; 13 matches involved Top 4 teams (including 148 GPS files) while 8 matches involved Bottom 4 teams (including 116 GPS files). Of the 21 matches, three matches involved two of the Top 4 teams (including 47 GPS files), one match involved two of the Bottom 4 teams (including 13 GPS files), and there were five matches that involved one Top 4 team and one Bottom 4 team (including 103 GPS files). The remaining 101 GPS files were obtained from Top 4 or Bottom 4 teams competing against Middle 4 teams.

Repeated High-Intensity Effort Activity

Player movement was recorded using a minimaxX S4 GPS unit (Catapult Innovations, Melbourne, Australia) sampling at 10 Hz. The GPS signal provided information on speed, distance, position, and acceleration. The unit also included a tri-axial accelerometer and gyroscope sampling at 100 Hz, to provide information on collisions and RHIE bouts. A RHIE

bout was classified as 3 or more high-acceleration ($\geq 2.79 \text{ m.s}^{-2}$), high-speed ($> 5.0 \text{ m.s}^{-1}$) or contact efforts with less than 21 seconds recovery between efforts.¹¹ Data were downloaded to a computer using Sprint 5.1 software (Catapult Innovations, Melbourne, Australia) and analysed for the total number of RHIE bouts, efforts per bout, duration of efforts and recovery between efforts. Acceptable reliability has been reported for total distance covered (intraclass correlation coefficient = 0.69, typical error of measurement = 2.0%), and distances covered at low- (intraclass correlation coefficient = 0.68, typical error of measurement = 4.3%), and high-speeds (intraclass correlation coefficient = 0.86, typical error of measurement = 7.9%).¹² In addition, the minimaxX units have been shown to offer a valid measurement of the collisions that commonly occur in rugby league, with the standard error of the estimate between collisions recorded by the minimaxX units and those coded from video recordings of the actual collision events reported to be 4.7%.¹³ The intraclass correlation coefficient for test-retest reliability and typical error of measurement for the detection of collisions was 0.95 and 3.0%, respectively. Finally, the validity of the minimaxX units to quantify repeated high-intensity effort bouts was determined by having players perform 2 to 4 bouts of 6 tackles, with each tackle separated by ~10 seconds of low-intensity activity. The standard error of the estimate between repeated high-intensity efforts recorded by the minimaxX units and those coded from video recordings of the actual repeated high-intensity effort bout was 5.6%.

Matches were filmed from an elevated position on the halfway line. Video footage from the 21 matches was obtained from the official competition broadcaster and manually analysed post-match. The Catapult GPS file time was synchronised with a stopwatch and then used to code the time at which the ball was grounded for a try. These times were then manually entered into the Catapult GPS software to identify when RHIE bouts occurred in

relation to tries scored and conceded. A frequency distribution representing 0-60 s, 61-120 s, 121-180 s, 181-240 s, and 241-300 s prior to scoring and conceding a try was established.

Statistical Analysis

The proportion of RHIE bouts occurring in each time period prior to scoring or conceding a try were calculated for each player. Based on these individual percentages, the overall means and standard deviations (SD) were then calculated. Differences in RHIE activity between Top 4 and Bottom 4, tries scored and conceded, and the period prior to scoring or conceding tries, were compared using a two-way ANOVA. The level of significance was set at $p < 0.05$. In addition, magnitude-based inferential statistics, in the form of effect sizes and 90% confidence limits were used to provide a practical and meaningful explanation of the results. 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.¹⁴ 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 $0.2 \times$ between-subject standard deviation (small ES). Effects with less certainty were classified as trivial and where the $\pm 90\%$ confidence limit (CL) of the ES crossed the boundaries of ES -0.2 and 0.2 , the effect was reported as unclear.

Results

Repeated High-Intensity Effort Activity across the Entire Game and in Relation to Tries Scored and Conceded

A total of 2,083 RHIE bouts were recorded. Of these bouts, 56.1% occurred within five minutes of a try. Top 4 teams performed a RHIE bout every 6.7 minutes (across the entire match) and a RHIE bout every 0.9 minutes in the 5 minutes prior to scoring or conceding a try. In comparison, Bottom 4 teams performed a RHIE bout every 10.0 minutes

(across the entire match) and a RHIE bout every 1.1 minutes in the 5 minutes prior to scoring or conceding a try.

Differences in Repeated High-Intensity Effort Activity between Top 4 and Bottom 4 Teams

Bottom 4 teams performed a significantly greater proportion of RHIE bouts within five minutes of a try than Top 4 teams (61.5% vs. 48.2%, $ES = 0.69 \pm 0.28$, $p = 0.0001$). Top 4 teams scored more tries ($ES = 1.03 \pm 0.48$, $p < 0.05$) and conceded fewer tries ($ES = 0.93 \pm 0.66$, $p < 0.05$) than Bottom 4 teams. Top 4 teams performed more RHIE bouts per try conceded ($ES = 0.74 \pm 0.51$, $p < 0.05$), and fewer RHIE bouts per try scored ($ES = 0.70 \pm 0.71$, $p = 0.10$) (Table 1).

Bottom 4 teams performed a significantly greater ($p < 0.001$) proportion of bouts five minutes prior to conceding ($45.0 \pm 21.8\%$) than scoring ($16.5 \pm 15.3\%$) tries. In addition, for Bottom 4 teams, the proportion of bouts in all 60 s periods prior to conceding a try were significantly greater ($p < 0.05$) than the same periods prior to scoring a try (Figure 1).

Bottom 4 teams performed a significantly greater proportion of RHIE bouts ($ES = 0.94 \pm 0.27$, $p < 0.001$) within five minutes of conceding a try than players from Top 4 teams; these findings were consistent across all time periods ($ES = 0.32 \pm 0.28$ to 0.60 ± 0.29 , $p < 0.05$). Top 4 teams performed a significantly greater proportion of bouts within five minutes of scoring a try than Bottom 4 teams ($ES = 0.48 \pm 0.30$, $p = 0.01$), and also performed a greater proportion of RHIE bouts 61-120 s ($ES = 0.37 \pm 0.31$, $p < 0.05$) and 121-180 s ($ES = 0.54 \pm 0.32$, $p < 0.01$) prior to scoring a try.

Nature of Repeated High-Intensity Effort Activity in Top 4 and Bottom 4 Teams

The nature of RHIE bouts was similar for Top 4 and Bottom 4 teams, with trivial to small differences between groups for the number of efforts per bout, the average duration of each effort and the average recovery between efforts ($ES = 0.06 \pm 0.29$ to 0.29 ± 0.31 , $p > 0.05$).

However, the maximum effort duration of Top 4 teams was significantly greater than Bottom 4 teams ($ES = 0.58 \pm 0.25$, $p < 0.05$) (Table 2).

Discussion

Our findings demonstrate that the majority of rugby league RHIE bouts occur at critical periods during match-play. Successful rugby league teams performed more RHIE bouts prior to conceding tries, while unsuccessful teams performed more bouts prior to scoring tries. These findings demonstrate that unsuccessful teams are required to work harder to score tries, while successful teams work harder to prevent tries.

To date, this is the largest study to investigate the RHIE demands of rugby league match-play, with data collected from a large number of matches and multiple teams. Consistent with the findings of others⁵ the present study found that the majority of RHIE bouts occurred at critical periods of match-play. From a total of 2,083 RHIE bouts, 56.1% occurred within five minutes of a try. Furthermore, the frequency of RHIE activity increased considerably in the 5 minute window before scoring or conceding a try, in comparison to RHIE activity across the entire match. These findings extend upon those of Austin et al⁵ by also documenting the proportion of RHIE bouts that occurred prior to scoring and conceding tries, in both winning and losing teams. Of the total number of RHIE bouts, 33.0% occurred within five minutes of conceding a try, while 20.2% occurred within five minutes of scoring a try. Whilst successful teams performed a similar proportion of bouts within five minutes of both scoring and conceding a try, unsuccessful teams performed significantly more RHIE bouts within five minutes of conceding a try. It is important to note that while unsuccessful teams performed more RHIE bouts within five minutes of a try, they also conceded significantly more tries and performed significantly fewer bouts per try conceded. Conversely, Top 4 teams performed significantly more RHIE bouts for each try conceded

than Bottom 4 teams. These findings suggest that successful teams perform as many, if not more RHIE bouts in defence, however their repeated-effort activity more often results in denial of a try.

Although the proportion of RHIE bouts were relatively consistent across the five minute period prior to conceding a try for Top 4 teams, a flurry of RHIE activity was observed in the minute prior to conceding a try in Bottom 4 teams. Based on the lower number of tries conceded, it is likely that well-developed defensive structures allows Top 4 teams to avoid these short passages of scrambling defence that also results in a spike in RHIE activity. Speculatively, these findings may also suggest that if Bottom 4 teams had better defence, or were able to convert attacking opportunities into points, then players may not be required to perform as many RHIE bouts, or experience the large increase in RHIE activity immediately prior to conceding tries.

The nature of RHIE bouts were remarkably similar between Top 4 and Bottom 4 teams, although the maximum duration of efforts within a RHIE bout was longer for Top 4 teams (7.3 ± 2.0 s vs. 6.2 ± 1.6 s). The longer maximal effort duration in the Top 4 teams is generally consistent with other data from this study (e.g. greater RHIE activity across the duration of the match). These findings suggest that (1) the maximum duration of efforts in RHIE bouts differs between Top 4 and Bottom 4 teams in the 5 minute period prior to tries, and (2) outside of the 5 minute period where tries are scored and conceded, the RHIE activity of Top 4 teams is greater than Bottom 4 teams. These findings are in general agreement with previous research that has shown that RHIE activity is greater in winning teams⁷ and at higher playing standards.³ Furthermore, elite players have been shown to engage in a greater number of RHIE bouts involving 3 or more efforts than semi-elite players, and fewer RHIE bouts involving 2 efforts.¹⁶ Moreover, in comparison to Bottom 4 teams, Top 4 teams perform a greater proportion of RHIE bouts involving very short (<10 s) recovery durations

between efforts and a smaller proportion of RHIE bouts involving very long (61-120 s) recovery durations between efforts (unpublished observations). Collectively, these findings demonstrate the ability of match-play RHIE activity to discriminate rugby league players of different playing standards.

Practical Applications

Our finding that over 50% of RHIE bouts occurred within five minutes of a try suggest that RHIE ability is a critical component of rugby league match-play. Moreover, the present findings suggest that the ability to sustain RHIE activity in defence is critical to success in rugby league. Training programs which develop the ability of players to perform and tolerate repeated defensive (i.e. tackling and wrestling) efforts may lead to fewer tries conceded and increased likelihood of competitive success. Furthermore, given that Bottom 4 teams are required to perform a greater frequency of RHIE bouts in order to score tries, repeated attacking efforts (i.e. involving sharp accelerations and changes of direction) may prepare players for these RHIE activities, while also allowing greater in reserve for the defensive RHIE bouts that follow these attacking phases of play.

Conclusion

In conclusion, this study investigated the nature and frequency of RHIE activity in relation to tries scored and conceded in successful and unsuccessful rugby league teams. The results demonstrate that RHIE activity is an important component of rugby league, as the majority of RHIE bouts occur during critical passages of play. Successful rugby league teams perform more RHIE bouts prior to conceding a try while unsuccessful teams perform more bouts prior to scoring a try. These findings suggest that unsuccessful teams are required to work harder to score tries, while successful teams are able to sustain RHIE activity for longer in defence before conceding tries.

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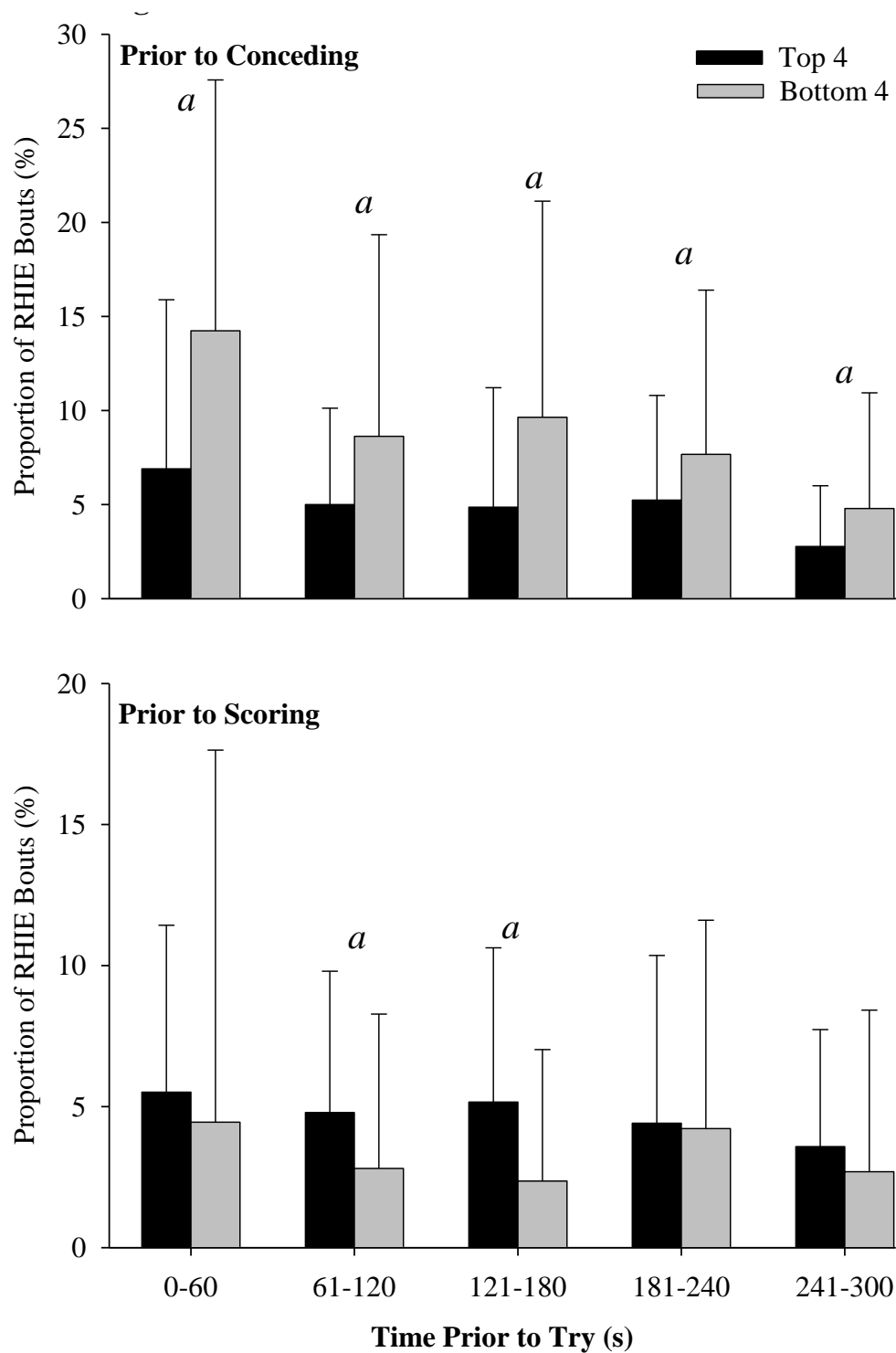


Figure 1. Proportion of RHIE bouts within 5 minutes of scoring a try in Top 4 and Bottom 4 teams.

Data are means \pm SD. RHIE = repeated high-intensity effort. *a* = small difference between Top 4 and Bottom 4 teams.

Table 1. Tries scored and conceded per match, and number of RHIE bouts performed per try scored and conceded for Top 4 and Bottom 4 teams.

	Top 4	Bottom 4	% Difference ($\pm 90\%$ CL)	ES ($\pm 90\%$ CL)
Tries Conceded (n)	3.6 ± 2.0	6.1 ± 3.0	$53.1 \pm 41.3^*$	0.93 ± 0.66
Tries Scored (n)	4.9 ± 2.2	2.7 ± 0.9	$-40.6 \pm 35.6^*$	-1.03 ± 0.48
RHIE Bouts per Try Conceded (n)	3.0 ± 2.1	1.6 ± 0.7	$-37.2 \pm 39.5^*$	-0.74 ± 0.51
RHIE Bouts Per Try Scored (n)	2.1 ± 1.7	3.6 ± 2.5	79.2 ± 41.2	0.70 ± 0.71

Data are means \pm SD. * denotes a significant difference ($p < 0.05$) between Top 4 and Bottom 4 teams. RHIE = repeated high-intensity effort. ES = effect size; CL = confidence limit.

Table 2. Nature of RHIE bouts performed by Top 4 and Bottom 4 teams.

	Top 4	Bottom 4	% Difference ($\pm 90\%$ CL)	ES ($\pm 90\%$ CL)
Efforts Per RHIE Bout (n)	3.6 ± 0.2	3.6 ± 0.5	-1.1 ± 2.9	-0.06 ± 0.29
Duration of Effort (s)	2.1 ± 0.3	2.2 ± 0.4	4.6 ± 5.1	0.29 ± 0.31
Max Duration of Effort (s)	7.3 ± 2.0	6.2 ± 1.6	$-14.3 \pm 9.2^*$	-0.58 ± 0.32
Recovery Between Efforts (s)	5.6 ± 1.4	5.9 ± 1.6	4.5 ± 8.7	0.20 ± 0.31

Data are means \pm SD. * denotes a significant difference ($p < 0.05$) between Top 4 and Bottom 4 teams. RHIE = repeated high-intensity effort. ES = effect size; CL = confidence limit.