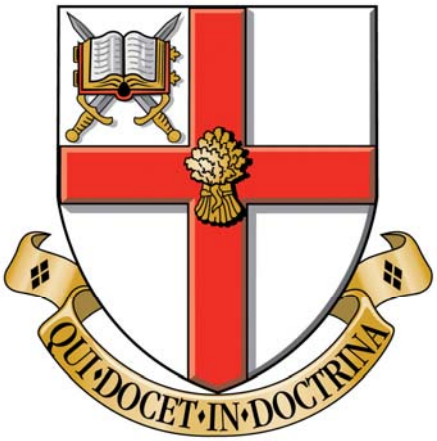

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Abstract

Purpose: This study compared the movement demands of players competing in matches from the elite Australian and European rugby league competitions. ***Methods:*** Global positioning system devices were used to measure 192 performances of forwards, adjustables and outside backs during National Rugby League (NRL; n = 88) and European Super League (SL; n = 104) matches. Total and relative distances covered overall and at low (0 to 3.5 $m \cdot s^{-1}$), moderate (3.6 to 5 $m \cdot s^{-1}$) and high (>5 $m \cdot s^{-1}$) speeds were measured alongside changes in movement variables across the early-, mid- and late-phases of the season. ***Results:*** The relative distance covered in SL matches (95.8 ± 18.6 $m \cdot min^{-1}$) was significantly greater (P<.05) than NRL matches (90.2 ± 8.3 $m \cdot min^{-1}$). Relative low speed activity (70.3 ± 4.9 $m \cdot min^{-1}$ *vs.* 75.5 ± 18.9 $m \cdot min^{-1}$) and moderate-speed running (12.5 ± 3.3 $m \cdot min^{-1}$ *vs.* 14.2 ± 3.8 $m \cdot min^{-1}$) was highest (P<.05) in the SL matches and relative high-speed distance was greater (P<.05) during NRL matches (7.8 ± 2.1 $m \cdot min^{-1}$ *vs.* 6.1 ± 1.7 $m \cdot min^{-1}$). ***Conclusions:*** NRL players have better maintenance of high-speed running between the first and second half of matches, and perform less low and moderate-speed activities, indicating that the NRL provides a higher standard of rugby league competition than the SL.

Key words: Rugby League; match demands; playing intensity; activity profiles; time-motion analysis

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Introduction

Rugby league is a contact team sport that is intermittent in nature, with periods of high- (running, high-speed running and sprinting) and low-speed activity (standing, walking and jogging) taking place over two 40 min halves. Players are typically classified into three positional groups (hit-up forwards, outside backs and adjustables) based upon commonalities in their field position and playing role.[1,2] Hit-up forwards (prop, second row and loose forward) cover less distance during a match, have a shorter playing time and are involved in more physical collisions, whereas outside backs (winger, full back and centre) and adjustables (half back, stand-off, and hooker) often travel greater distances during a match, play for the longest time and are associated with running in open spaces and supporting offensive plays.[1-4]

The match–running activities of team sports are dependent upon the standard of competition encountered. For example, team sport players competing at the highest standard typically perform more high-speed running and sprinting than players competing at a sub-elite standard.[5,6] These findings have been confirmed in rugby league match-play, with professional players demonstrating higher playing intensities than semi-professional and junior rugby league players.[7,8] Conversely, lower ranked teams might perform more high-speed running to counter deficiencies in technical ability during match play.[9]

The Australian National Rugby League (NRL) and European Super League (SL) are the most notable elite competitions, with the NRL anecdotally regarded as the world's highest standard of competition. Only one study has compared the playing patterns of NRL and SL teams using video analysis,[10] noting a greater proportion of time spent by the NRL teams in their defensive third of the pitch and a higher number of hit-ups in the opponent's defensive third. The introduction of Global Positioning System (GPS) technology into the rugby league environment has seen several studies examine the movement and physiological match

demands imposed on players during both NRL[3,11,12] and SL[2,13] matches. Similar absolute distances of between 3,000 and 8,000 m have been reported for NRL[1,3,12] and SL[2] matches. While some studies report higher relative distances for NRL players (~106 $m \cdot min^{-1}$)[14] others have reported similar values of 85-95 $m \cdot min^{-1}$ in both the NRL[11,12] and SL.[2] However, problems in comparing studies using different movement analysis technologies[14] and the timing of these studies make comparisons between competitions difficult. To date, no study has made direct comparisons of the match demands between professional rugby league players from the Australian and European competitions. A study of this nature would be useful to elucidate any differences between the two competitions that may explain, at least in part, the disparate tactical approaches to match play between the NRL and SL teams. Furthermore, given the dominance of the Australian national team (NRL players) in competition with other European nations, such as England and France, such a study might help to inform coaching practices in Europe. Therefore, this study compared the movement demands of players competing in matches from the elite Australian and European rugby league competitions.

Methods

With Institutional ethical approval (approval HMS09/1407), data were collected during the 2011 season from one professional team participating in the Australian National Rugby League (NRL) and one professional team from the European Super League (SL) competitions. All data were desensitized by a third party before analysis so that researchers were unable to identify players. Only data from the respective league's domestic season was included. Based on previous studies, and in accordance with normal coaching practice, players were sub-categorised into three positional groups of outside backs, adjustables and hit-up forwards (referred to as forwards hereafter).[1,2] A total of 192 match performances were

recorded, comprising 104 SL matches and 88 NRL matches. The win percentage of the matches analysed was 44% and 50%, and the mean score deficit were 10 ± 5 and 9 ± 5 points for the NRL and SL, respectively.

Time-motion analysis was undertaken using portable GPS devices (SPI-Pro; 5Hz, GPSports, Canberra, Australia) and an in-built tri-accelerometer (100 Hz). The reliability and accuracy of these units has been reported previously.[15,16] All players were accustomed to wearing the GPS devices during training and matches. Players were pre-fitted with an appropriately sized vest housing the portable GPS unit between the scapulae. A standard squad shirt (tightly fitted) was worn over the top of the vest. The GPS device was fitted to the vest of the player upon entering the field for the warm-up. All data were downloaded to a computer using SPI Ezy V2.1 (GPSports, Canberra, Australia) and analysed *post hoc* using Team AMS V2.1 software (GPSports, Canberra, Australia).

Data for the entire match were recorded for outside backs (n = 72), adjustables (n = 52) and forwards (n = 68) that totalled 192 performances. Changes in movement demands were also analysed between the first and second half (188 performances), with players who played for <5 min of each half removed from the analysis. In accordance with previous studies in soccer,[6] changes in movement variables across three different time phases of the season were also considered (192 performances); namely early phase (NRL: n = 29 performances; SL: n = 26 performances, 10 matches), mid-phase (NRL: n = 30 performances; SL: n = 32 performances, 9 matches) and late-phase (NRL: n = 29 performances; SL: n = 46 performances, 6 matches). The variables recorded were duration on the pitch (min), total distance covered (m), relative distance covered ($m \cdot min^{-1}$), and absolute and relative distances covered at low (0 to 3.5 $m \cdot s^{-1}$), moderate (3.6 to 5 $m \cdot s^{-1}$) and high (>5 $m \cdot s^{-1}$) speeds. The use of these broad speed categories were deemed appropriate based on the limitations associated

5Hz GPS technology.[14,15] For each player, only the time spent actively on the pitch was analysed.

Statistical Analysis

Data were initially analysed for violations of normality and homogeneity of variances using the Shapiro-Wilk statistic and Levene's test, respectively. Further checks for sphericity were performed using Mauchley's test. Separate factorial (group [2] x position [3]) analyses of variance (ANOVA) were conducted on each of the dependent variables. In addition, separate mixed model repeated measures ANOVA (group [2] x time [2]) were used to assess differences in total distance, low speed-activity, moderate speed and high-speed running between the first and second half of matches. Finally, multivariate ANOVA (group [2] x time [3]) was used to assess differences in relative distance, low-speed activity, moderate and high-speed running between early-, mid- and late-season phases of the season. Where appropriate, *post hoc* analyses were conducted using independant samples *t*-tests with a Holm-Bonferonni adjustment to assess for positional differences between the two groups. Statistical significance was set at $P<.05$ and data are reported as mean ± standard deviation (SD) unless otherwise stated. Effect sizes (ES) were calculated as the difference between the means divided by the pooled standard deviation. Effect sizes were classified as: trivial <0.2, small 0.21-0.6, moderate 0.61-1.2, large 1.21-1.99, and very large >2.0.[17]

Results

A significant interaction, revealing trivial to moderate differences in playing times, was found between positional groups in NRL and SL matches ($F_{2, 186} = 3.82$, $P = .024$; ES = -0.08 to 0.79), with *post hoc* analyses revealing that only NRL adjustables had a greater total playing time than SL adjustables ($t = 2.76$, $P = .008$; ES = 0.79). A significant moderate difference in the total distance covered was found between positional groups in NRL and SL

matches ($F_{2, 186}$ = 10.47, *P* <.001; ES = -0.63 to 0.93). *Post hoc* analysis revealed that SL forwards covered greater distances than those players in NRL matches (*t* = 3.28, *P* = .002; ES = -0.63), but that NRL adjustables covered greater distances than their SL counterparts (*t* = 2.55, *P* = .013; ES = 0.93). There was a small difference in the relative distances covered between groups, with lower values in NRL compared to SL matches ($F_{1, 186}$ = 12.76, *P* < .001; ES = -0.38). In addition, there were trivial to moderate differences in relative distance covered between positional groups in NRL and SL matches ($F_{2, 186}$ = 5.29, *P* = .006; ES = -1.18 to 0.10), with *post hoc* analysis indicating a higher relative distance covered by forwards in SL matches compared to the NRL (*t* = 4.78, *P* <.001; ES = -1.18). Relative distance covered in low-speed activity ($F_{1, 186}$ = 16.16, *P* <.001; ES = -0.43) and moderate-speed running ($F_{1, 186}$ = 16.22, *P* <.001; ES = -0.48) was highest in the SL matches, while relative high-speed running distance was greater during NRL matches ($F_{1, 186}$ = 15.80, *P* <.001; ES = 0.54). Low-speed activity showed trivial to moderate differences between positions in the NRL and SL ($F_{2, 186}$ = 5.68, *P* = .004; ES = -1.06 to 0.15), although moderate-speed running was not significatly different ($F_{2, 186}$ = 1.69, *P* = .187; ES = -0.95 to -0.28). Trivial to moderate positional differences in high-speed running were observed between NRL and SL matches ($F_{2, 182}$ = 5.87, *P* = .003; ES = -0.07 to 1.2). *Post hoc* analysis revealed that forwards performed more low-speed activity in the SL (*t* = -4.74, *P* < .001; ES = -1.06), while adjustables (*t* = 5.01, *P* < .001; ES = 1.16) and outside backs (*t* = 2.69, *P* = .010; ES = 0.69) performed more high-speed running in NRL matches (Table 1).

No main effect indicated the average playing time was not different between the first (NRL: 37.0 ± 8.2 min; SL: 36.4 ± 12.2 min) and second half (NRL: 37.6 ± 10.5 min; SL: 36.4 ± 10.9 min) of matches ($F_{1, 186}$ = 1.37, *P* = .243; ES = 0.04-0.14), nor were these values different between groups ($F_{1, 186}$ = 0.141, *P* = .708; ES = -0.06). A main effect indicated relative distance reduced from the first to the second half ($F_{1, 186}$ = 8.08, *P* = .005) but

reductions were similar between NRL (92.6 ± 9.4 m·min^{-1} cf. 87.4 ± 8.8 m·min^{-1}, respectively; ES = 0.58) and SL (102.6 ± 31.4 m·min^{-1} cf. 96.7 ± 27.2 m·min^{-1}, respectively; ES = 0.18) matches. ($F_{1, 182}$ = 0.03, P = .863). A main effect revealed reductions in low-speed activity between halves ($F_{1, 186}$ = 4.77, P = .030), although changes for NRL (72.2 ± 5.8 cf. 68.3 ± 5.4 m·min^{-1}; ES = 0.69) and SL (80.2 ± 26.5 cf. 77.0 ± 22.6 m·min^{-1}; ES = 0.11) matches were not different ($F_{1, 186}$ = 0.051, P = .822). Moderate-speed running was reduced from the first to the second half ($F_{1, 186}$ = 4.87, P = .028), but was not different between NRL (12.8 ± 3.7 cf. 12.2 ± 3.7 m·min^{-1}; ES = 0.16) and SL (15.2 ± 5.2 cf. 14.3 ± 5.0 m·min^{-1}; ES = 0.16) matches ($F_{1, 186}$ = 0.18, P = .674). A main effect revealed reductions in high-speed running from the first to the second half ($F_{1, 186}$ = 24.26, P <0.001), with significant changes in SL (7.3 ± 3.1 cf. 5.4 ± 2.4 m·min^{-1}; ES = 0.68) but not NRL (7.5 ± 3.3 cf. 6.8 ± 2.5 m·min^{-1}; ES = 0.25) matches ($F_{1, 186}$ = 4.46, P = .036) (Figure 1).

Relative distance covered was not different across the early- (NRL: 91.4 ± 8.0 m·min^{-1}; SL: 91.9 ± 18.0 m·min^{-1}), mid- (NRL: 91.5 ± 9.0 m·min^{-1}; SL: 95.6 ± 13.3 m·min^{-1}) and late-season phases (NRL: 87.6 ± 7.6 m·min^{-1}; SL: 98.2 ± 21.9 m·min^{-1}) ($F_{2, 186}$ = 0.246, P = .782; ES = -0.01 to 0.48). However, a main effect for group revealed a higher relative distance between groups ($F_{1, 186}$ = 5.29, P = .023; ES = -0.38). Low-speed activity remained unchanged between the early- (NRL: 70.7 ± 4.4 m·min^{-1}; SL: 72.4 ± 14.1 m·min^{-1}), mid- (NRL: 70.5 ± 5.4 m·min^{-1}; SL: 75.2 ± 10.8 m·min^{-1}) and late-season phases (NRL: 69.6 ± 5.1 m·min^{-1}; SL: 77.4 ± 19.4 m·min^{-1}) ($F_{2, 186}$ = .415, P = .661; ES = -0.29 to 0.23). However, a main effect for group revealed a higher low-speed activity in SL players ($F_{1, 184}$ = 6.94, P = .009; ES = -0. 43). Moderate-speed running remained unchanged between the early- (NRL: 13.1 ± 3.4 m·min^{-1}; SL: 13.5 ± 4.1 m·min^{-1}), mid- (NRL: 13.0 ± 3.7 m·min^{-1}; SL: 14.4 ± 3.1 m·min^{-1}) and late-season phases (NRL: 11.3 ± 2.6 m·min^{-1}; SL: 14.6 ± 4.1 m·min^{-1}) ($F_{2, 186}$ = .746, P = .475; ES = -0.26 to 062). Again, a main effect for group revealed a higher

moderate-speed running in SL players ($F_{1, 186}$ = 10.14, P = .002; ES = -0.49). High-speed running remained consistent across the early- (NRL: 7.2 ± 2.3 m·min^{-1}; SL: 6.0 ± 1.6 m·min^{-1}), mid- (NRL: 7.6 ± 2.5 m·min^{-1}; SL: 5.9 ± 1.6 m·min^{-1}) and late-season phases (NRL: 6.7 ± 2.4 m·min^{-1}; SL: 6.2 ± 1.9 m·min^{-1}) ($F_{1, 186}$ = 0.479, P = .620; ES = -0.21 to 0.42), and was higher in NRL players compared to SL ($F_{1, 182}$ = 13.34, P < .001; ES = 0.53).

Discussion

This is the first study to directly compare the match demands of elite rugby league teams from the Australian and European competitions. Our study compared 192 match performances from the same season in an attempt to ascertain if the demands differed between the NRL and SL competitions. The total and relative distance covered during each of the respective competitions was similar to that reported previously in NRL[1,3,12] and SL[2] matches. However, we observed that values for forwards and adjustables in this study were slightly higher than values reported for the same positional groups reported by Waldron et al.[2] These small differences (~6 m·min^{-1}) are potentially explained by the larger number of performances measured in the present study, and match-to-match variability in activity profiles of team sport.[18,19] Collectively, these findings suggest that our data are representative of the movement demands imposed on players during the Australian NRL and European SL competitions.

This study revealed that adjustables in the NRL matches had more game time and covered greater absolute distances per match than the same positional group in the SL matches. This was in contrast to forwards and outside backs, whose respective game time in the NRL and SL matches was similar. While small differences in total absolute and relative match intensity was apparent between groups, it would appear that players in the NRL and SL matches achieve this in a different manner. Although SL players spend a greater

proportion of match play in low-speed activity and moderate-speed running, our observations confirm a superior relative high-speed running in the NRL than the SL matches. Moreover, specific positional groups were responsible for the discrepancies between competitions, with NRL adjustables and outside backs performing more high-speed running than their SL counterparts, and SL forwards performing more low-speed activity than NRL forwards. The amount of high-speed running has been used to differentiate between standards of competition in team sports,[6-8] with top-class teams performing more high-speed running than moderate standard teams. Accordingly, findings in this study provide evidence to support the anecdotal claims that the activity profiles of the NRL differ from the SL. Our findings also demonstrate that the greater volume of high-speed running in the NRL can be attributed to positional groups who predominantly run in open spaces and support offensive plays.[1,4]

While the influence of match score, possession and tactical decisions cannot be ignored, reductions in high-speed running towards the end of a rugby league match are known to be indicative of fatigue.[13,20,21] While both groups of players performed similar relative amounts of high-speed running in the first half, second half high-speed running was ~9% and ~27% lower for NRL and SL matches, respectively. The small reduction in second half high-speed running in NRL players accounts for the greater total volume of higher speed running observed in the Australian matches. These findings also suggest that, across the course of match play, NRL matches were played at consistently higher intensities than SL matches. Differences in physical capacity are known to influence high-speed running performance during team sports,[22,23] which might explain the discrepancies in physical demands observed between NRL and SL matches. In particular, greater prolonged high-speed running capacity of NRL adjustables and outside backs would have enabled more high-speed running by these players during a game.[22] Tactical strategies implemented by Australian coaches might also enable the maintenance of high-speed running during NRL matches. For

example, the introduction of second half interchange players in soccer increases the overall distance covered in high-speed running.[6] While the total match time of the most typically interchanged players (i.e. forwards) was not different between NRL and SL, a more effective use of interchanges to replace fatiguing players could have enabled the smaller reduction in second half high-speed running observed in NRL matches. Such observations might also be influenced by the pacing strategies adopted by players during matches. Indeed, our findings reaffirm those of Waldron et al.,[13] who reported that interchange players in the European Super League typically adopt higher intensities in their first exercise bout, followed by a lower, maintainable intensity in the second. Players in the NRL might therefore be encouraged to adopt an even pacing strategy that enables only small reductions in high-speed running in the second half of a match.

The relative distance, low-speed activity, moderate-speed and high-speed running were not different across the early-, mid- and late-season phases for both NRL and SL matches. These data differ to those reported in soccer, where total distance and high-speed running increase towards the end of the season.[6,24] These data also suggest that SL matches involve players covering greater relative distances, but that this is achieved through more low-speed activity. Our findings therefore support anecdotal claims that matches in the SL competition are slower than those of the NRL.

Practical Applications

These findings enable coaches to better understand the activity profiles of elite rugby league teams that allow players to perform at the highest standard. While total relative distance provides an indicator of overall match demand, practitioners should consider the way players achieve that intensity. Coaches should also develop players' capacity to maintain high-speed running in the second half of matches and resist fatigue that might have a negative

outcome in terms of running performance. The ability to maintain more high-speed running in a match appears to be an important characteristic of teams playing in a better standard of competition. Coaches should also consider the role of individual players and how they contribute to the maintenance of overall match intensity.

Conclusions

In the first study to directly compare the movement demands of a NRL and SL team during the same season, we have provided evidence to substantiate the anecdotal claims that the NRL provides a higher standard of rugby league competition than the SL. This is based on the observations that in NRL players, high-speed running is better preserved between the first and second half of matches, and that SL matches comprise more low-speed activity throughout the season. NRL adjustables and outside backs performed more high-speed running than their SL counterparts. This suggests that in NRL, greater emphasis is placed on the involvement of these positions and their role during matches.

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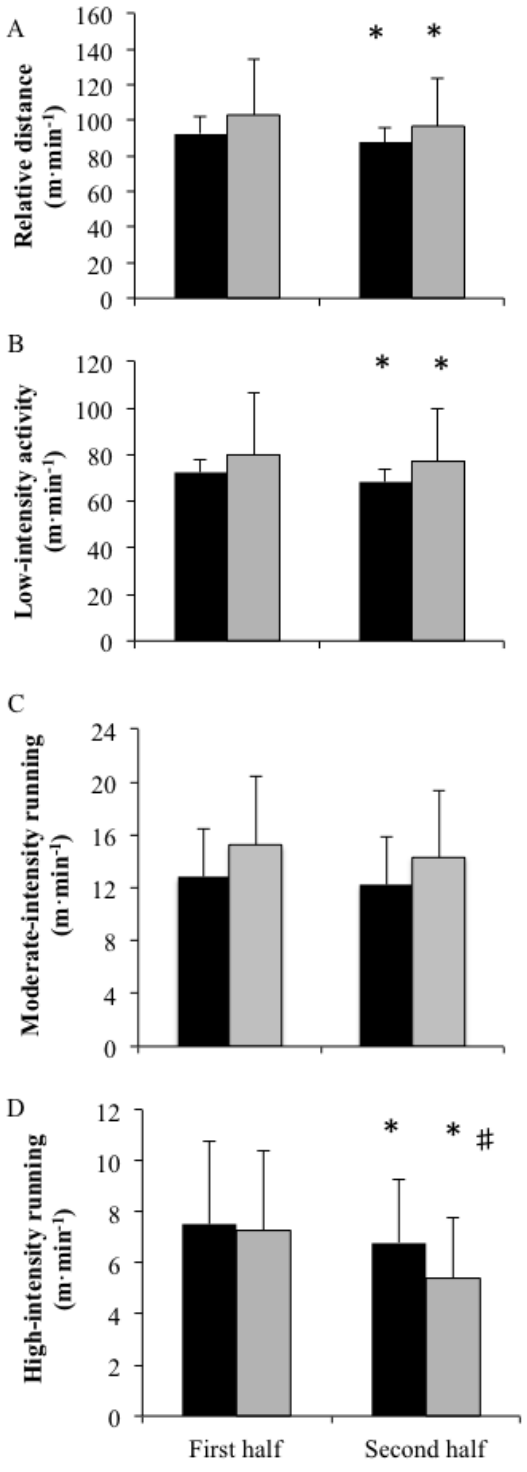

Figure 1

Figure 1 Changes in relative distance (A), low-speed activity (B), moderate-speed running (C) and high-speed running (D) between the first and second half of National Rugby League (NRL; black) and Super League (SL; light grey) matches. * indicates significant difference between first and second half. ♯ indicates significant difference between NRL and SL.

Table 1 Match characteristics for National Rugby League (NRL) and Super League (SL) forwards, adjustables, outside backs and all players.

	National Rugby League				Super League			
	Forwards (*n* = 29)	Adjustables (*n* = 29)	Outside backs (*n* = 30)	All (*n* = 88)	Forwards (*n* = 39)	Adjustables (*n* = 23)	Outside backs (*n* = 42)	All (*n* = 104)
Time (min)	56.7 ± 16.4	82.8 ± 8.9†	85.8 ± 3.9	75.2 ± 17.0	57.9 ± 15.8	69.7 ± 23.4	83.9 ± 12.9	70.5 ± 21.0
Total distance (m)	4948 ± 1370†	7973 ± 1160†	7381 ± 518	6775 ± 1686	5733 ± 1158	6766 ± 1495	7133 ± 1204	6526 ± 1396
Relative distance ($m \cdot min^{-1}$)	88.0 ± 7.8†	96.2 ± 7.5	86.5 ± 6.3	90.2 ± 8.3*	101.7 ± 14.0	104.4 ± 27.2	85.6 ± 10.7	95.8 ± 18.6
Low speed activity ($m \cdot min^{-1}$)	70.6 ± 5.1†	73.2 ± 4.5	67.2 ± 3.2	70.3 ± 4.9*	81.1 ± 12.4	82.8 ± 23.4	66.3 ± 7.3	75.5 ± 15.9
Moderate speed running ($m \cdot min^{-1}$)	11.8 ± 3.6	14.6 ± 3.2	11.0 ± 1.9	12.5 ± 3.3*	15.1 ± 3.4	15.7 ± 4.5	12.7 ± 3.4	14.2 ± 3.8
High-speed running ($m \cdot min^{-1}$)	5.5 ± 2.0	8.2 ± 2.2†	7.8 ± 2.1†	7.2 ± 2.4*	5.6 ± 1.9	5.9 ± 1.7	6.6 ± 1.5	6.1 ± 1.7

Note: * indicates significant difference between NRL and SL ($P<0.05$); † indicates significant difference between NRL and SL matches for same positional group ($P<0.05$). Low-speed activity = 0 to 3.5 $m \cdot s^{-1}$, moderate-speed running = 3.6 to 5.0 $m \cdot s^{-1}$ and high-speed running = >5.0 $m \cdot s^{-1}$.