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Title: The movement and physiological demands of international and regional men's touch rugby matches.

Running head: Movement and physiological demands of touch rugby

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ABSTRACT

This study compared the internal and external match demands imposed on international and regional standard male touch rugby players. The study adopted a cohort design with independent groups. Twelve international players (mean age 27.8 ± 6.2 y, body mass 72.8 ± 3.7 kg, stature 174.5 ± 5.4 cm) and nine regional players (mean age 25.5 ± 5.5 y, body mass 74.2 ± 7 kg, stature 174.1 ± 7 cm) were analysed during nine competitive matches from the 2013 season. Movement demands were measured using a 5 Hz global positioning system (GPS), alongside heart rate and session rating of perceived exertion (s-RPE) to quantify internal load. Total distance covered by international players was lower than regional players (2265.8 ± 562.3 cf. 2970 ± 558.9 m, $p < 0.05$). However, international players had greater relative distance (137.1 ± 13.6 cf. 126.2 ± 17.2 m·min⁻¹) due to shorter playing times per match ($p < 0.05$). Absolute high speed running (>14 km·h⁻¹) was not different between groups ($p > 0.05$), but relative high speed running (39.3 ± 12.0 cf. 26.0 ± 13.6 m·min⁻¹) was higher for international players. Regional players performed more absolute low speed activity (≤ 14 km·h⁻¹) than international players ($p < 0.05$), whereas relative low speed activity was not different between groups ($p > 0.05$). Very high speed running (>20 km·h⁻¹) distance, bout number and frequency, peak and average speed were all greater in international players ($p < 0.05$). Higher average heart rate, summated heart rate and s-RPE ($p < 0.05$) indicated higher internal loads during matches for regional players. These data indicate that performance in men's touch rugby is characterised by more relative high speed running and better repeated sprint capacities in higher standard players.

Key words - GPS; team sport; sprinting; elite; sub-elite

INTRODUCTION

Touch rugby (touch) is an intermittent high intensity team sport played globally. Like many teams sports, touch players perform frequent periods of high intensity running (such as sprinting) separated by periods of low intensity activity (such as standing, walking and jogging) (26). Touch is played over 2 x 20 min halves with a 3-min half-time period and is played on a smaller area than other rugby codes (70 x 50 m cf. 100 x 70 m). Teams comprise six active players and eight interchange players, adopting an unlimited substitution rule that allows players multiple off-pitch recovery periods during matches (37). This is in contrast to other codes where rules permit a limited number of interchanges (rugby league: 10 changes from 4) or a fixed number of substitutions where the changed player cannot return (rugby union: 7 changes from 7; rugby sevens: 5 changes from 5). As with these other rugby codes, the ball must only be passed backwards with the aim to score as many tries as possible. In contrast, touch players do not perform high impact collisions, and instead tackling is limited to placing a single hand on the ball carrying player (1). On completing the touch, the defending team retreats 5 m and the attacking team restart play by passing the ball between the legs of a player.

Few studies have investigated the internal and external loads imposed on players during touch matches. O'Conner (25) reported average match heart rates of Australian national players to be greater than 90% of their maximum heart rates and that 11% of match time was spent performing high intensity activity. However, since the study by O'Conner (25), touch rugby match duration has increased from 30 to 40 min, meaning the demands placed currently on players are likely to have changed. Ogden (26) reported that elite New Zealand touch rugby players covered up to 3.1 km per match, with 0.9 km of this at high intensity ($>12 \text{ km}\cdot\text{h}^{-1}$). However, Ogden (26) failed to report distances relative to the time spent on the pitch, meaning these data misrepresent the actual work intensity performed by players during matches (2). Indeed, this is particularly important in touch rugby as the unlimited substitution

rule allows players to have multiple and differing lengths of time on the pitch. Ogden (26) also utilised a 1 Hz global positioning system (GPS) device to measure player movements, which are known to be less accurate than GPS devices with higher sampling frequencies (2, 9, 20).

Given that limited research exists on the match demands of touch rugby, strength and conditioning coaches have little information on how to optimally prepare players for competition. Knowledge of the internal (heart rate and rating of perceived exertion) and external (speed and distance covered) match demands enable strength and conditioning coaches to tailor training sessions to the sport's demands (27, 13). Such sport specific conditioning is an effective way to prepare players for competition, promoting relevant and specific physical development whilst aiding the transfer of improvements to a competitive environment (23). Knowing these demands can also identify optimal player recovery times (33). The greater the physiological load, the more recovery time is required to avoid injury or a reduced ability to train (29). Furthermore, it can provide quantitative information over reductions in players' work-rate that might be helpful in determining optimal timings for substitutions (32). Knowledge of how match demands differ between playing standards will also enable better preparation for the transition from sub-elite to elite status (27). Previous research from team sports including football (4), hockey (19), rugby league (30) and rugby sevens (16) all indicate differences between players of differing standard. Elite players tend to perform more higher intensity exercise (especially during the latter stage of matches), cover greater distances relative to playing time, achieve greater average sprint distances and compete at higher percentages of their maximum heart rate (4, 16). However, such data does not exist for touch players and therefore limits the strength and conditioning coach working with such groups in devising appropriate training practices. Accordingly, the purpose of this study was to quantify and compare the internal and external match demands on international and regional standard male touch players.

METHODS

Experimental Approach to the Problem

Using an independent cohort design this study examined the match running demands, heart rate and perceptual responses during competitive international and regional touch matches. Twenty one international and regional touch players were analysed during competitive matches from official international and regional tournaments during the 2013 season. Portable global positioning system (GPS) technology, heart rate (HR) and session RPE (s-RPE) responses were used to assess external and internal match demands.

Subjects

Twenty-one adult male players (mean age 26.2 ± 6 years; body mass 73.5 ± 6.3 kg; stature 175.3 ± 6.2 cm) provided written informed consent to participate. Regional players ($n = 9$; mean age 25.5 ± 5.5 years, body mass 74.2 ± 7 kg and stature 174.1 ± 7 cm) were players representing the north west of England while international players ($n = 12$; mean age 27.8 ± 6.2 years, body mass 72.8 ± 3.7 kg and stature 174.5 ± 5.4 cm) were from the same Men's Open representative squad (World Ranking = 4th, Federation of International Touch). Where players competed at both regional and international standard, only performances at the highest standard were used for analysis. This comprised 55 national match performances (five games, 11 ± 1 players per match) and 33 regional match performances (four matches, 8 ± 1 players per match) for analysis. All matches were played outdoors on dry grass between 09.50 and 18.00 hours, at an average temperature of $16.5 \pm 1.2^{\circ}\text{C}$. All international matches were won (mean score difference of 8 ± 4 points), while regional matches resulted in one draw, the rest were won (mean score difference of 2 ± 2 points). All players were injury free and any match files where a player sustained injury were discarded from the analysis. Players undertook their normal pre-match preparation and post-match recovery strategies. The procedures for this study were approved by the Faculty of Applied Sciences Research Ethics Committee.

Procedures

Thirty minutes prior to each match, players were issued with a GPS unit (GPSports, SPI-Pro, 5 Hz, Canberra, Australia) that was housed in a custom-made vest under the playing shirt, with the unit located between the scapulae. The GPS model used possesses good test-retest reliability with a coefficient of variation of 1.6% and 2.3% for speed and distance, respectively (36). The number of satellites for GPS signal transmission averaged 9 ± 1 (5-11 range) which is considered optimal for assessing human movement using GPS technology (20). Players also wore a heart rate monitor (Polar Electro, Finland, Oy), with data transferred telemetrically and stored on the GPS device. A digital watch synchronised to Greenwich Mean Time recorded the start and end times of each half. In addition, the times players entered and left the field of play during matches were recorded live, via hand notation, and were later used to truncate each GPS file for analysis. Therefore, only data when the player was active on the field of play were analysed. All GPS data were downloaded using SPI Ezy v.2.1 (GPSports, Canberra, Australia) and analysed using Team AMS v. 2.1 (GPSports, Canberra, Australia). Based on similar studies quantifying match demands of elite rugby league and rugby sevens (16, 35) and that broad speed zones are more appropriate when using 5 Hz GPS devices (20), the following were reported for each player: total absolute (m) and relative ($\text{m}\cdot\text{min}^{-1}$) distance covered; absolute (m) and relative ($\text{m}\cdot\text{min}^{-1}$) distance covered in low speed activity ($<14 \text{ km}\cdot\text{h}^{-1}$), high speed running ($>14 \text{ km}\cdot\text{h}^{-1}$) and very high speed running ($>20 \text{ km}\cdot\text{h}^{-1}$); number of very high speed efforts per min; average very high speed distance (m); peak and average speed ($\text{km}\cdot\text{h}^{-1}$); **low:high** speed movement (the ratio between **low and high** intensity performed) for time and distance. Heart rate ($\text{b}\cdot\text{min}^{-1}$) was used to calculate each individual's average percentage of peak heart rate, with peak heart rate taken as the highest value obtained during any single match. A peak value established this way has been shown to equal the maximum obtained during incremental tests (31). Summated heart rates were also calculated based on the method outlined by Edwards (10): summated heart rate (AU) = (duration in zone 1 x 1)+(duration in zone 2 x 2)+(duration in zone 3 x

3)+(duration in zone 4 x 4)+(duration in zone 5 x 5); where zone 1 = 50-60%, zone 2 = 60-70%, zone 3 = 70-80%, zone 4 = 80-90% and zone 5 = 90-100% of peak heart rate. In addition, players individually provided (away from teammates to avoid peer pressure) a rating of perceived exertion using Borg's CR-10 RPE scale (5) 20 min after a match, which was multiplied by their playing duration to provide a measure of internal load (AU) referred to as session RPE (s-RPE) (12).

Statistical Analysis

Violations of normality and homogeneity were assessed using the Shapiro-Wilk and Levenes tests, respectively. Separate independent sample *t*-tests were performed on all variables, using an alpha level of <0.05 to detect differences between international and regional match demands. Effect sizes and magnitude-based inferences (3) were also calculated for GPS variables between international and regional players. Threshold probabilities for a substantial effect based on the 90% confidence limits (CL) were: <0.5% most unlikely, 0.5–5% very unlikely, 5–25% unlikely, 25–75% possibly, 75–95% likely, 95–99.5% very likely, >99.5% most likely. Thresholds for the magnitude of the observed change for primary performance variables were determined as the between-participant standard deviation (SD) x 0.3, 0.9 and 1.6 for a small, moderate and large effect, respectively. Effects with confidence limits across a likely small positive or negative change were classified as unclear (18). All calculations were completed using a predesigned spreadsheet (17).

RESULTS

Total match playing time was shorter for international players compared to regional players ($p<0.001$). However, the number of playing bouts or time per bout was not different between standards ($p=0.982$; Table 1). While regional players covered a greater total distance (m) per

match ($p < 0.001$), international players covered more distance ($p = 0.001$) per minute of playing time ($\text{m} \cdot \text{min}^{-1}$). There was no difference between standards in the absolute high speed running distance covered ($p = 0.880$). However, relative to per minute of playing time ($\text{m} \cdot \text{min}^{-1}$), international players covered more high speed distance ($p = 0.001$). International players covered less absolute low speed activity ($p < 0.001$), but this was not different between standards when expressed relative to playing time ($p = 0.163$). The low:high speed movement for both distance ($p = 0.001$) and time ($p = 0.002$) was also lower in international players. All movement demands for international and regional players are presented in Table 1.

***** Insert Table 1 about here *****

While the total absolute (m) and relative ($\text{m} \cdot \text{min}^{-1}$) very high speed distance was greater in international compared to regional players (both $p < 0.001$), the average very high speed distance per effort (m) was not different between the playing standards ($p = 0.189$). International players performed a greater number and frequency of very high speed efforts per match than regional players ($p = 0.003$). Likewise, peak speed ($p < 0.001$) and average match speed ($p = 0.001$) were also higher in international compared to regional players. All running speed data for international and regional players are presented in Table 2.

***** Insert Table 2 about here *****

During matches international players performed at lower percentages of their peak heart rate compared to national players (80.6 ± 4.3 cf. $83.5 \pm 5.1\%$, respectively, $p = 0.031$; Mean difference $\pm 90\% \text{CL} = 2.9 \pm 1.9\%$, Unclear). Accordingly, summated heart rates (3360 ± 706 cf. 5641 ± 2086 AU, respectively; Mean difference; $\pm 90\% \text{CL} = -2281; \pm 745$ AU, Most likely moderate ↓) and s-RPE (73 ± 31 cf. 143 ± 51 AU, respectively; Mean difference; $\pm 90\% \text{CL} = -70; \pm 17$ AU, Most likely very large ↓) were lower for international compared to regional players (both $p < 0.001$).

DISCUSSION

This is the first study to compare the movement and physiological demands of international and regional standard touch players. We have shown that touch players of both international and regional standard competition performed at slightly higher running intensities during a match when compared to rugby sevens players (16), but substantially higher than those reported for rugby league (14, 35) and rugby union (6). Such observations are not surprising given the absence of collisions, shorter playing time, unlimited interchange and larger player number to playing area ratio in touch. However, these data confirm the relevant physiological characteristics required to play touch rugby that will be useful in designing sport-specific conditioning practices to prepare players for the highest standard of competition.

Regional touch players covered 31% greater absolute distance compared to international players, contradicting previous research that shows higher standard players cover more distance than their sub-elite equivalents (16, 30). However, international touch players covered ~13.5% greater relative distance than regional players during their time on the field. While absolute low speed activity was higher in regional players, relative low speed activity was not different between standards. International players however, covered *moderately* (~50%) more high speed running relative to playing time and achieved higher peak and average match speeds than their regional counterparts. These findings are most likely explained by regional players spending a *larger* amount of time (~20%) on the field during a match compared to international players. Shorter time on the field in international players therefore enables a higher quality of work to be achieved per minute of playing time. Accordingly, our findings are consistent with those from other rugby codes (16, 30) and re-affirm that increased high speed running during matches is a fundamental characteristic of higher standard team sports.

There was a *large/very large* difference in the **low:high** speed movements of international players (**7.2 s low:1 s high and 2.9 m low:1 m high**) compared to regional players (**13.8 s low:1 s high and 5.5 m low:1 m high**). This indicated that for every second of high speed running, regional players spent twice as much time in low speed activity compared to the international players. Less low speed activity time between sprint efforts indicates that higher standard players are capable of tolerating repeated high intensity efforts more frequently throughout a match (10). A shorter total playing time and shorter time per playing bout would also enable international players to tolerate faster and more frequent sprints during a match. Indeed, that interchanges during a match are self-managed by players themselves, rather than dictated by the coach, suggests some international players are more capable of pacing their involvement by using shorter playing bouts. Alternatively, the strategy issued to some players in advance is to use shorter bouts, which with greater playing experience and a higher awareness of the game demands means international players adopt a more robust interchange strategy. By playing shorter bouts these players do not accumulate the noxious stimuli that cause a reduction in maximal intensity running (24), meaning very high speed running performance is preserved. Despite mean values being different between international (148 s) and regional (273 s) players, the large inter-individual variability in bout time meant differences between groups were unclear. The small group of players who were not interchanged during matches probably explains this variability. Despite this, we propose that a proportion of international players adopt a more structured interchange strategy that enables more high intensity running during a match. Such information could be used for interval-based training to aid conditioning whilst better simulating the demands of competition. Furthermore, when preparing players for international competition, a coach could consider increasing training time at higher intensities and reduce recovery to as little as 1:3.4 s (i.e. the minimum work to rest ratio in international matches), exposing players to a 'worst-case' scenario (15). Combined with the running characteristics, these data suggest that coaches should emphasise developing a touch player's ability to perform repeated high intensity exercise bouts with minimal recovery in order to compete at the highest standard.

Futures studies should examine the physical qualities that determine repeated high intensity running in touch players and optimal work-to-rest ratios to better prepare players for competition.

The greater absolute and relative very high speed running distances performed by players in international matches are consistent with other rugby codes (30). Although individual distance between the standards was similar, our data clearly support that greater overall distance covered in very high speed running by international players is attributed to their higher frequency of these movements during a match. Indeed, international players performed, on average, one very high intensity run every minute of play whereas regional players performed one every 2 min. These data emphasize the importance to coaches of including multiple sprint training sessions when preparing touch players for competition (16), with players maintaining these high intensity efforts over distances of 5-10 m.

Despite the higher running intensity of touch, average heart rate values for both international and regional players were similar to those reported in other rugby codes (7, 8, 35). Such observations are likely to reflect the influence of collisions in increasing the heart rate response during rugby league and union (21, 28). Both summated heart rate and s-RPE were also greater for players during regional matches. These differences are accounted for by the greater total playing time players spent on the pitch and indicate an increased internal load for regional players during match play.

Several factors might explain the observed differences between international and regional standard touch players. Elite team sport athletes are reported to have superior physical capacities than sub-elite standard players (13, 16). As such, data taken from a small cohort

of participants ($n = 15$; Beavan, unpublished observations) showed only small differences ($p > 0.05$) in intermittent endurance running capacity (Yo-Yo intermittent recovery test) between regional (1588 ± 457 m) and international (1786 ± 689 m) players. Factors such as the quality of opposition, fellow team mates' ability and tactical decision making might also have played a role to explain the differences (13). For example, in this study, players in both groups self-selected when they interchanged, with international players selecting shorter playing bouts. These tactical decisions are likely to influence a player's running capacity and therefore overall match performance.

PRACTICAL APPLICATIONS

For the first time, this study provides appropriate match data that enables practitioners to better understand the demands of men's touch rugby by comparing elite and sub-elite standards. Indeed, training to improve player capacity or player selection should be based on data observed from the highest standard of competition to which players aspire to compete. These data suggest that performance in men's touch rugby is characterised by more high intensity running and better repeated sprint capacities in higher standard players. Practitioners should therefore emphasise these components as part of their conditioning programmes to better prepare players for competition. Coaches are also provided with appropriate work-to-rest ratios that will enable design of training practices to prepare players for matches, including the 'worst-case scenarios'. Future studies should examine the physical qualities that relate best to these characteristics in touch players so that appropriate testing and training programmes can be designed. Furthermore, a better understanding of the factors that influence interchange strategies would help to optimise performance in multiple-bout sports such as touch rugby.

References

1. Allen, G. Activity patterns and physiological responses of elite touch players during competition. *J Hum Mov Studies* 17: 207-215, 1989.
2. Aughey, R. Australian football player work rate: Evidence of fatigue or pacing. *Int J Sports Physiol Per* 5: 394-405, 2010.
3. Batterham, AM, and Hopkins, WG. Making meaningful inferences about magnitudes. *Int J Sports Physiol Perf* 1: 50-57, 2006.
4. Bradley, P, Di Mascio, M, Peart, D, Olsen, P, and Sheldon, B. High-intensity activity profiles of elite soccer players at different performance levels. *J Strength Cond Res* 24: 2343–2351, 2012.
5. Borg, G, Ljunggren, G, and Ceci, R. The increase of perceived exertion, aches and pain in the legs, heart rate and blood lactate during exercise on a bicycle ergometer. *Eur J Appl Physiol Occup Physiol* 54: 343-349, 1985.
6. Cahill, N, Lamb, K, Worsfold P, Heady, R, and Murray, S. The movement characteristics of English Premiership rugby union players. *J Sports Sci* 31: 229-237, 2013.
7. Coutts A, Reaburn, P, and Abt, G. Heart rate, blood lactate concentration and estimated energy expenditure in a semi-professional rugby league team during a match: a case study. *J Sport Sci* 21: 97-103, 2003.
8. Deutsch, MU, Maw, GJ, Jenkins D, and Reaburn, P. Heart rate, blood lactate and kinematic data of elite colts (under-19) rugby union players during competition. *J Sports Sci* 16: 561-570, 1998
9. Duffield, R, Reid, M, Baker, J, and Spratford, W. Accuracy and reliability of GPS devices for measurement of movement patterns in confined spaces for court-based sports. *J Sci Med Sport* 13: 523-525, 2010.

10. Edg, EJ, Bishop, D, Hill-Haas, S, Dawson, B, and Goodman, C. Comparison of muscle buffer capacity and repeated-sprint ability of untrained, endurance-trained and team-sport athletes. *Eur J Appl Physiol* 96: 225-34, 2006.
11. Edwards, S. *The Heart Rate Monitor Book*. Sacramento, CA: Fleet Feet Press, 1993.
12. Foster, C, Florhaug, JA, Franklin, J, Gotschall, L, Hrovatin, LA, Parker, S, Doleshal, P, and Dodge, C. A new approach to monitoring exercise training. *J Strength Cond Res* 15: 109-115, 2001.
13. Gabbett, TJ. Influence of playing standard on the physical demands of professional rugby league. *J Sports Sci* 31: 1125-1138, 2013.
14. Gabbett TJ, Jenkins DG, and Abernethy, B. Physical demands of professional rugby league training and competition using microtechnology. *J Sci Med Sport* 15: 80-86, 2012.
15. Gabbett TJ, Polley C, Dwyer DB, Kearney S, and Corvo, A. Influence of field position and phase of play on the physical demands of match-play in professional rugby league forwards. *J Sci Med Sport*, <http://dx.doi.org/10.1016/j.isams.2013.08.002>, 2013
16. Higham, D, Pyne, D, Anson, J, and Eddy, A. Movement patterns in rugby sevens: Effects of tournament level, fatigue and substitute players. *J Sci Med Sport* 15: 277-282, 2011.
17. Hopkins, W. Spreadsheets for analysis of controlled trials, with adjustment for a subject characteristic. *Sportscience* 10: 46-50, 2006.
18. Hopkins, WG, Marshall, SW, Batterham, AM, and Hanin, J. Progressive statistics for studies in sports medicine and exercise science. *Med Sci Sports Exerc* 41: 3-13, 2009
19. Jennings, D, Cormack, S, Coutts, A, and Aughey, R. International field hockey players perform more high-speed running than national level counterparts. *J Strength Cond Res* 26: 947-952, 2012.

20. Jennings, D, Cormack, S, Coutts, A, Boyd, L, and Aughey, R. The validity and reliability of GPS units for measuring distance in team sport specific running patterns. *Int J Sports Physiol Perform* 5: 328-341, 2010.
21. Johnston, RD and Gabbett, TJ. Repeated-sprint and effort ability in rugby league players. *J Strength Cond Res* 25: 2789-2795, 2011.
22. Impellizzeri, FM, Marcora, SM, Castagna, C, Reilly, T, Sassi, A, Iaia, FM, and Rampinini, E. Physiological and performance effects of generic versus specific aerobic training in soccer players. *Int J Sports Med* 27: 483-492, 2006.
23. Kennett, D, Kempton, T, and Coutts, A. Factors affecting exercise intensity in rugby-specific small-sided games. *J Strength Cond Res* 26: 2037-2042, 2012.
24. Nicolò, A, Bazzucchi, I, Lenti, M, Haxhi, J, Scotto di Palumbo A, and Sacchetti, M. Neuromuscular and metabolic responses to high-intensity intermittent cycling protocols with different work-to-rest ratios. *Int J Sports Physiol Perform* 9: 151-160, 2014.
25. O'Conner, D. Time-motion analysis of elite touch players. In: *Science and Football IV. 2002: Fourth World Congress of Science and Football*. W. Spinks, T. Reilly and A. Murphy, eds. London, Routledge, 2002. pp 126-131.
26. Ogden, T. (2010). Time motion analysis and physiological profile of elite New Zealand touch players during competition, (Masters Thesis), AUT University. Available at; <http://aut.researchgateway.ac.nz/bitstream/handle/10292/1035/OgdenT.pdf?sequence=3>.
27. Reilly, T, Thomas T, and Whyte, G. The specificity of training prescription and physiological assessment: A review. *J Sports Sci* 27: 575-589, 2009.
28. Singh, TK, Guelfi, KJ, and Landers, G, Dawson, B, and Bishop, D. Reliability of a contact and non-contact simulated team game circuit. *J Sports Sci Med* 9: 638-642, 2010.

29. Singh, T, Guelfi, K, Landers, G, Dawson, B, and Bishop, D. A comparison of muscle damage, soreness and performance following a simulated contact and non-contact team sport activity circuit. *J Sci Med Sport* 14: 441-446, 2011.
30. Sirotic, A, Coutts, A, Knowles, H, and Catterick, C. A comparison of match demands between elite and semi-elite rugby league competitors. *J Sports Sci* 27: 203-211, 2009.
31. Suarez-Arrones, L, Nunez, F, Portillo, J, and Mendez-Villanueva, A. Running demands and heart rate responses in men rugby sevens. *J Strength Cond Res* 26: 3155-3159, 2012.
32. Sykes, D, Twist, C, Hall, S, Nicholas, C, and Lamb, K. Changes in Locomotion rates during senior elite rugby league matches. *J Sports Sci* 29: 1263-1271, 2011.
33. Sweet, T, Foster, C, McGuigan, M, and Brice, G. Quantitation of resistance training using the session rating of perceived exertion method. *J Strength Cond Res* 18: 796-802, 2004.
34. Waldron, M, Daniels, M, Highton, J, and Twist, C. Preliminary evidence of transient fatigue and pacing during interchanges in rugby league. *Int J Sports Physiol Perform* 8: 157-64, 2013.
35. Waldron, M, Twist, C, Highton, J, Worsfold, P, and Daniels, M. Movement and physiological demands of elite rugby league using portable global positioning systems. *J Sports Sci* 29: 1223-1230, 2011.
36. Waldron, M, Worsfold, P, Twist, C, and Lamb, K. Concurrent validity and test-retest reliability of a global positioning satellite system (GPS) and timing gates to assess sprint performance variables. *J Sports Sci* 29: 1613-1619, 2011.
37. Walsh, J, Heazlewood, I, and Climstein, M. Modelling touch football (touch rugby) as a Markov process. *Intl J of Sports Sci and Eng* 6: 203-212, 2012.

Table legends

Table 1. Movement characteristics of international and regional men's touch players during match play

Table 2. Very high speed running and running speed characteristics of international and regional men's touch players during match play

ACCEPTED

Table 1

Variable	International Mean ± SD	Regional Mean ± SD	Difference (± 90% confidence limits)	Interpretation International vs. Regional
Total playing time (min:s)	16:52 ± 5:50	24:15 ± 7:07 *	-7:23 (± 2:28)	Most likely large ↓
Average bout time (s)	148 ± 221	273 ± 353	-126 (± 115)	Unclear
No. of bouts	9.2 ± 2.4	9.2 ± 3.9	0 (± 1.3)	Unclear
Total distance (m)	2265.8 ± 562.3	2970.6 ± 558.9*	-704.8 (± 206.4)	Most likely large ↓
Total distance (m·min ⁻¹)	137.1 ± 13.6	126.2 ± 17.2*	11.0 (± 5.2)	Most likely moderate ↑
Low speed activity (m)	1650.6 ± 593.8	2404.9 ± 616.4*	-754.4 (± 217.3)	Most likely large ↓
Low speed activity (m·min ⁻¹)	98.2 ± 6.4	100.6 ± 6.5	-2.0 (± 2.4)	Unclear
High speed running (m)	619.9 ± 155.2	564.9 ± 232.7	55.0 (± 76.6)	Very likely small ↑
High speed running (m·min ⁻¹)	39.3 ± 12.0	26.0 ± 13.6*	13.3 (± 4.8)	Most likely moderate ↑
Low:High speed distance(X m low: 1 m high)	2.9 ± 1.4	5.5 ± 4.0*	-2.6 (± 1.2)	Most likely large ↓
Low:High speed time (X s low: 1 s high)	7.0 ± 3.2	14.0 ± 11.6*	-6.9 (± 3.5)	Most likely very large ↓

Note: Significant difference ($p < 0.05$) between international and regional players indicated by *. Threshold probabilities for a substantial effect were: <0.5% most unlikely, 0.5–5% very unlikely, 5–25% unlikely, 25–75% possibly, 75–95% likely, 95–99.5% very likely, >99.5% most likely. Thresholds for the magnitude of the observed change in each dependent variable were determined as the between-participant $s \times 0.3$, 0.9 and 1.6 for a small, moderate and large effect, respectively. Cohen's d effect sizes were classified as: trivial <0.2, small 0.2–0.6, moderate 0.6–1.2, large 1.2–2.0, and very large >2.0 (15)

Table 2

Variable	International Mean ± SD	Regional Mean ± SD	Difference (± 90% confidence limits)	Interpretation International vs. Regional
Very high speed running distance (m)	118.68 ± 59.9	68.44 ± 44.54*	49.7 (± 18.7)	Most likely moderate ↑
Very high speed running distance (m·min ⁻¹)	7.67 ± 4.40	3.08 ± 2.30*	4.6 (± 1.2)	Most likely moderate ↑
Average very high speed running distance (m)	7.37 ± 2.15	6.29 ± 3.52	1.1 (± 1.1)	Very likely small ↑
No. very high speed bouts (#)	16.22 ± 7.6	11.30 ± 6.78*	-4.9 (± 2.6)	Most likely moderate ↑
Very high speed bouts per minute (#·min ⁻¹)	1.0 ± 0.5	0.5 ± 0.37*	0.5 (± 0.2)	Most likely moderate ↑
Peak speed (km·h ⁻¹)	26.10 ± 1.79	24.49 ± 2.26*	1.6 (± 0.8)	Most likely moderate ↑
Average speed (km·h ⁻¹)	8.21 ± .76	7.51 ± 1.02*	0.7 (± 0.3)	Most likely moderate ↑

Note: Significant difference ($p < 0.05$) between international and regional players indicated by *. Threshold probabilities for a substantial effect were: <0.5% most unlikely, 0.5–5% very unlikely, 5–25% unlikely, 25–75% possibly, 75–95% likely, 95–99.5% very likely, >99.5% most likely. Thresholds for the magnitude of the observed change in each dependent variable were determined as the within-participant $s \times 0.3$, 0.9 and 1.6 for a small, moderate and large effect, respectively. Cohen's d effect sizes were classified as: trivial <0.2, small 0.2-0.6, moderate 0.6–1.2, large 1.2–2.0, and very large >2.0 (15)