The specificity of rugby union training sessions in preparation for match demands

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Abstract

Purpose: Investigations into the specificity of rugby union training practices in preparation for competitive demands has predominantly focussed on physical and physiological demands. The evaluation of the contextual variance in perceptual strain or skill requirements between training and matches in rugby union is unclear, yet holistic understanding may assist to optimise training design. This study evaluated the specificity of physical, physiological, perceptual and skill demands of training sessions compared with competitive match-play in pre-professional, elite club rugby union. Methods: Global positioning system (GPS) devices, video capture, heart rate (HR), and session ratings of perceived exertion (sRPE) were used to assess movement patterns, skill completions, physiologic, and perceptual responses, respectively. Data were collected across a season (training sessions n=29; matches n=14). Participants (n=32) were grouped in playing positions as: outside backs, centres, halves, loose forwards, lock forwards, and front row forwards. Results: Greater total distance, low-intensity activity, maximal speed and metres per min were apparent in matches compared to training in all positions ($P<0.02$; $d>0.90$). Similarly, match HR, and sRPE responses were higher than those recorded in training ($P<0.05$; $d>0.8$). Key skill completions for forwards (i.e., scrums, rucks and lineouts) and backs (i.e., kicks) were greater under match conditions than in training ($P<0.001$; $d>1.50$). Conclusion: Considerable disparities exist between the perceptual, physiological, and key skill demands of competitive matches versus training sessions in pre-professional rugby union players. Practitioners should consider the specificity of training tasks for pre-professional rugby players to ensure the best preparation for match demands.

Introduction

The specificity of training principle states that training adaptations are closely related to the training stimulus, and is considered important to optimise physical performance [1]. Training practices in rugby union have predominantly focussed on the physical and physiological demands of match-play alone [2-4]. Notably, this contrasts the multifaceted position-specific demands of rugby union competition [5,6]. The differences in physical and physiological characteristics of rugby union training and competitive matches have been reported [3,4], yet no data exists to evaluate contextual variance in perceptual strain or skill requirements. Omitting the considerable perceptual and skill demands of rugby union provides a limited analysis of training and match-play. Accordingly, additional analysis of rugby union is required to understand the position-specific, broad and multifactorial demands of rugby union. Of particular importance is the specificity of current training practices in preparation for competitive match demands.

Rugby coaching practices are anecdotally known to extensively utilise strategies that remove the performance context from the skill (e.g., unopposed or passive skills practice) [7]. It is unclear if this interpretation is justified, and if accurate, whether these training practices differ from rugby union match activities, as suggested in other sports [8]. The current literature clearly recommends designing skills-focused training sessions to be representative of the competitive environment, which imitates the variable nature of a match [7,9]. While some evidence suggests that match-specific or games-based training has increased in professional teams [3,4], this may point to a difference in training method used between elite and pre-elite coaches. Providing a broad, multidisciplinary analysis of training and match demands could afford insight into such a discrepancy between coaches and playing standards. This data may have particular implications for pre-professional players, because the understanding of match demands is proposed as the first step in the development of an elite rugby union player [10].

Although the physical and physiological demands of professional [5,11] and adolescent [2] rugby union matches have been established, less is known about these demands at the pre-professional standard. Importantly, elite club, pre-professional rugby union provides a platform for the development of emerging players. For example, current elite club rugby players are often presently, or previously involved in professional clubs. The Australian Rugby Union development and competition pathway indicates elite club, pre-professional rugby as a consistent component in player development. Identifying the physical, physiological, perceptual and skill demands could have important implications for players transitioning into professional rugby union. Understanding specific skill outputs and physical demands during matches may also assist in identifying potential training limitations and providing opportunities to enhance performance outcomes. The aim of this study was to examine the position-specific physiological, perceptual and skill demand requirements of pre-professional rugby players in matches and training sessions. The specificity of current on-field rugby training sessions was then compared with competitive match-play demands.

Methods

Participants

Thirty-two male Premier Grade club rugby union players volunteered to participate in this study (24 ± 4 y, 88 ± 20 kg, 177 ± 10 cm). At the time of data collection, participants were highly trained individuals, free of injury and collectively had experienced four different standards of representative rugby union playing experience: a) Queensland Reds U20 (n = 3), b) Australian U20 (n = 3), c) National Rugby Championship (n = 12), d) Super 15 Rugby experience (n = 10). Additionally, participants were completing at least three rugby sessions (two training, one match) and two to three resistance training sessions per week (on-field training time = 147 ± 46.7 min·week^{-1}). All participants provided written informed consent, and ethics approval for study procedures was provided by the University Human Research Ethics Committee.

Overview

An observational time-motion analysis study was conducted throughout a season of a Premier Grade rugby union competition (Brisbane, Australia) to examine the movement patterns, skill demands and perceptual exertion required of pre-professional players. Players were familiar with all measures as part of their normal monitoring routine. Data were collected throughout the competition period (spanning 19 weeks) to evaluate the key physical (i.e., movement patterns, skill completions), physiological (i.e., heart rate), and subjective markers (i.e., perceived exertion) of rugby union performance during on-field rugby training sessions (n = 29; 294 observations) and competitive matches (n = 14; 146 observations). Training sessions typically consisted of the following elements: warm-up (12.9 ± 7.1 min·week^{-1}), conditioning (19.4 ± 12.9 min·week^{-1}), forward (24.8 ± 5.1 min·week^{-1}) and backs (20.8 ± 5.0 min·week^{-1}), unit skills, captain’s run (15.2 ± 7.9 min·week^{-1}), and modified game periods (20.4 ± 7.2 min·week^{-1}).

Eleven injury-free Premier Grade squad players were randomly selected for involvement each week to accommodate the limited global positioning satellite (GPS) devices available to record movement patterns. Participants wore the same GPS unit during that week’s training and match. The frequency of skill completions was coded using video footage after each session. Similarly, a session rating of perceived exertion (sRPE) was recorded 30 min following training and match-play. Data were divided into six position groups: outside backs (n = 57 training, 26 match (85.5 ± 9.5 min·match^{-1}) observations); wingers (n = 29 training, 13 match (88.4 ± 4.2 min·match^{-1}) observations; centres (n = 21 training, 11 match (85.3 ± 12.6 min·match^{-1}) observations); halves (n = 53 training, 25 match (87.2 ± 10.1 min·match^{-1}) observations); loose forwards (n = 63 training, 36 match (87.9 ± 5.6 min·match^{-1}) observations); lock forwards (n = 36 training, 14 match (81.7 ± 16.2 min·match^{-1}) observations), and front row forwards (n = 64 training, 34 match (80.8 ± 20.8 min·match^{-1}) observations) to allow for specific comparisons between playing positions.

Measures

External Load

Participants wore a GPS device (15 Hz; SPI HPU GPSports, Canberra, Australia) during all training sessions and competitive matches. The devices were harnessed to the upper thoracic spine between the superior sections of the scapulae. Raw GPS data were downloaded post-session to a personal laptop running specialised software (Team AMS, GPSports, Canberra, Australia). This GPS device reportedly demonstrates a 1.9% typical error of measurement (TEM) and −0.20 intra-class correlation (ICC) for total distance measured, and a TEM of 8.1% and ICC of −0.14 for peak speed [12]. The movement pattern variables included for analysis comprised: total distance, mean speed, sprint count and very high-intensity activity (VHIA; >20 $km \cdot h^{-1}$) [13,14]. GPS variables were processed as both absolute forms and relative to time.

Internal Load

Players wore a heart rate (HR) transmitter belt (T34, Polar Electro-Oy, Kempele, Finland), with the data recorded synchronously with the GPS device and downloaded post-session to a personal laptop running specialised software (Team AMS, GPSports, Canberra, Australia). Recorded game and training HR was categorised into six pre-determined HR zones. The HR maximum, mean HR and HR Zone 4-6 were included in the data analysis. The HR zones were categorised as: Zone 4 (160-170 $beats.min^{-1}$), Zone 5 (170-180 $beats.min^{-1}$) and Zone 6 (180-220 $beats.min^{-1}$) [15]. HR Zones were presented as the time spent within each zone throughout training and match-play. Perceptual measures of internal load were collected using the sRPE method [16]. Participants recorded sRPE (Borg's CR-10 scale) 30 min after all training and competitive matches using a smartphone application (SportsMed Global, Newstead, Australia).

Skill Notational Analysis

Video recordings of all sessions were performed using a digital camcorder (Legria HF R506, Canon, Tokyo, Japan) positioned on a stationary tripod 3−5 m above the height of the playing field. The footage was taken from a vantage point 10–20 m from the field either side of the 22 m and halfway lines. All video footage was recorded onto a digital SD card (SDHC™ UHS-I, SanDisk, Sydney, Australia). All video recordings were then analysed post-session for frequency and volume of key match event demands that are specific to backs and forwards [6,11,17,18]. One analyst performed coding of each video recording. The key match event demands analysed in absolute form and relative to time included: passes, ball carries, tackles, kicks, kicks under pressure, rucks, lineouts (attack and defence), and scrums. Analysis of ten match and training files were performed in duplicate to ensure the reliability of the data. Reliability of all notational skill variables demonstrate 0.0 – 8.5% standard error of measurement and ICC equal to 0.93 – 1.0.

Statistical Analysis

Data are reported as a mean ± standard deviation unless otherwise specified. Movement pattern and skill variable values were normalised to time and divided into positional playing groups for both training and match comparisons. A one-way analysis of variance with Tukey corrected post hoc analysis was used to determine differences between training and match-play data specific to playing positions. The analysis was performed using Statistical Package for Social Sciences (IBM SPSS v.22, Chicago, USA). Significance was accepted when $P<0.05$. Standardised effect sizes (Cohen's *d*) were calculated by dividing the mean difference (between positional groups and training versus matches) by the average of their standard deviations. Effect sizes were then evaluated based on the smallest worthwhile difference, whereby an effect size of ≤0.2 is trivial, 0.2–0.49 is small, 0.5–0.79 is medium, and ≥0.8 is large [19].

Results

External Load

Differences between Positional Groups

Running speed variables for matches and training are shown in Table 1. Outside backs (*P*<0.001; *d*=1.63) and halves (*P*=0.02; *d*=1.13) covered greater total distances than front row forwards during match-play. Outside backs, centres and halves also accumulated greater total distances than loose forwards and front row forwards in training (*P*<0.001–0.004; *d*=0.84–1.47). Outside backs completed more VHIA during competitive matches than other playing positions (*P*<0.001; *d*=1.54–3.46), with the exception of centres only (*P*=0.321; *d*=0.8). Similarly, centres completed more VHIA than all forwards (*P*<0.001–0.04; *d*=1.51–2.70), while halves also attained more VHIA than front row forwards during competitive matches (*P*<0.001; *d*=1.01–2.47).

Outside backs and halves achieved greater maximum speeds than loose forwards, lock forwards and front row forwards during competitive matches (*P*<0.001–0.01; *d*=1.35–3.34). Centres and loose forwards also attained higher speeds than front row forwards during competitive match-play (*P*<0.009; *d*=1.04–2.29). Outside backs and halves maintained a higher average speed than front row forwards during competitive match-play (*P*<0.001–0.01; *d*=1.09–1.64). Centres and halves attained a higher sprint count during competitive match-play than loose forwards, lock forwards and front row forwards, while outside backs were higher in both categories than front row forwards (P<0.001–0.02; d=0.98–2.90). Notably, maximum speeds were higher during matches for outside backs, centres, halves and loose forwards than in training (P<0.001–0.01; d=0.93–2.00).

Differences between Training and Matches

Comparisons between matches and training showed that outside backs, loose forwards and front row forwards all covered greater total distances compared with training (P<0.001; d=1.01–2.05). Relative analyses ($m \cdot min^{-1}$) indicated that loose and front row forwards completed higher activity output during competitive match-play compared with full training sessions (P=0.013–0.015; d=1.70–1.82). There were no differences observed in absolute comparisons between competitive matches and training for VHIA (P=0.083–0.982; d=0.01–0.61).

Internal Load

Heart Rate

Figure 1 indicates differences between competitive matches and training for average HR and HR Zones 4-6. Results show more time was spent within HR Zones 4, 5 and 6 during competitive matches than training sessions in all positional groups, except centres in HR Zone 4 (P<0.001–0.02; d=0.80–2.62).

Session Rating of Perceived Exertion

Higher sRPE values were reported after competitive matches when compared to training for all positional groups (Figure 2, P<0.001–0.03; d=1.24–2.92).

Skill Notational Analysis

Differences between Positional Groups

Skill completion frequencies for backs and forwards are displayed in Table 2 and Table 3, respectively. All forward positions completed more ruck involvements during matches than any backline player (P<0.001; d=1.42–4.96), with lock forwards completing more involvements than front row forwards (P=0.012; d=1.03). Outside backs made more kicks than centres and halves during competitive matches (P<0.001; d=1.26–1.62). However, the halves made more kicks under pressure and passes than the outside backs and centres (P<0.008; d=1.14–2.52).

Differences between Training and Matches

Competitive match-play involved greater quantities of opposed rucking, scrum, lineout attack and lineout defence occurrences (P<0.001; d=1.62–8.25) for all forward positions compared with training sessions in absolute and relative conditions. Competitive matches involved a higher number of kicks in absolute and relative analyses for outside backs than training

(*P*<0.001; *d*=1.52). Likewise, centres accrued more kicks under pressure in competitive matches than in training (*P*<0.001; *d*=1.28–1.71).

Discussion

This study is the first to provide a broad, multidisciplinary comparison of the physical, perceptual and skill demands between training and matches in rugby union. The principal finding is the consistently higher perceptual strain and key skill completions during competitive pre-professional rugby union matches than in training. These results may suggest a lack of specificity in current rugby union training practices at the pre-professional standard. The results of this study also provide evidence reinforcing the requirement for position-specific physiological, movement patterns and key skill demand training practices. Comparisons with previous literature indicate that differences are present between the physical and skill demands of professional and pre-professional rugby union players [5,13,20]. This study may provide an evidence-based framework to assist coaches in developing players transitioning into professional players.

Comparisons of activity profiles between professional and pre-professional players (5505 ± 433 indicate both similarities (5750 ± 295 and 5448 ± 733) [6,11] and differences (5198 ± 652 and 6953) [5,13] in total distances (m) covered during matches. There were fewer in-match tackles (5.1 ± 1.9 vs. 23.1 ± 14), rucks (12.9 ± 2) and mauls (3.1 ± 0.2) in this study compared with professional players (combined rucks & mauls 66.9 ± 15.8) [21]. Further, scrum frequencies in pre-professional players (22.2 ± 1) were comparable to some previous reports (29 ± 6) [22], but less than others (38.1 ± 1.15) [21]. The findings of the present study show a much higher number of lineout formations in pre-professional (23.5 ± 0.7) when compared with professional rugby matches (11 ± 4) [22]. These results indicate that pre-professional rugby union is characterised by a similar number of scrums, and a greater number of lineouts when compared with professional rugby union players. This may be explained by differences in skill level, and consequently tactics, within pre-professional rugby players. The results reinforce the need for greater training emphasis on forward-specific skill sets, using specific competitive match practice of lineouts and scrummage situations during training in pre-professional players. The differences in physical and skill related demands may require specific training strategies to prepare players for professional standards of rugby union.

Similar to previous studies [5,11,20], the current findings highlight important positional differences, which are indicative of specific characteristics and reinforce the necessity to individualise training prescriptions. Particularly apparent and consistent with studies in professional players, positional differences were found in maximum speed, sprint count and very-high-intensity activity ranges. Backline players accumulated greater distances in these zones due to their specific traits (e.g., greater speed) [6,22] and game requirements (e.g., set-plays) that allows for higher running speeds to be achieved. In contrast, match demands experienced by forwards reflected greater amounts of physical interactions (e.g., tackles, rucks, scrums and lineouts) compared to the backs. Such observations might indicate a need for training to incorporate repeated exposures to high-intensity activities (static and dynamic), with a greater emphasis on speed and endurance for backs, versus strength and physical contacts for forwards.

Interestingly, activity pattern data suggest that pre-professional rugby union players may be well prepared for the high-intensity and sprint running demands of match-play (Table 1). This result is in contrast with existing literature typically reporting training sessions to involve significantly less high-intensity running demands than competition [2,3]. It is possible that this is an example of differences in elite and pre-elite coaching practices, whereby coaches of professional players may be more likely to utilise games-based scenarios that are known to involve less high-intensity running [4]. Alternatively, these coaches may implement a high volume of repeated sprint scenarios in training based on evidence that repeat sprint ability is an important quality for team sport performance [23]. These findings demonstrate the need for more research providing comparisons between matches and training.

Training approaches aim to develop specific athletic qualities (e.g., physical, psychological, perceptual and technical/tactical skills) to maximise preparedness for the competitive environment. This is consistent with the longstanding belief among team sport coaches that players should train the way they play [24]. In practice, this requires training to simulate and represent the inherently dynamic and variable nature of competitive match-play [7,9,25]. However, clear differences in load were apparent in the current data, with both heart rate (Figure 1) and perceptual (sRPE; Figure 2) responses higher during matches than in training. This may be reflective of the greater physiological, skill-demand, emotional and psychological stressors involved in decision-making scenarios occurring throughout competitive matches [13]. Rugby matches involve substantial incidences and time spent within intense static or low-movement situations (e.g., rucks, scrums). These bouts of physical effort will register as low-intensity activity by a GPS; however, intense static muscular contractions will produce marked HR responses[13]. The results of the study appear to substantiate this, with players experiencing greater absolute and relative incidences of skill scenarios such as contested kicking, lineouts, ruck and scrums during matches when compared with training (Table 2 and 3).

These findings appear to support the anecdotal belief that training sessions largely consist of skills performed in isolated environments removed from performance contexts [8]. From a match skill demand perspective, previous research has shown changes in decision making based on player positioning [26] and variations in movement based on specific task constraints [27]. The results of the present study would appear to support the need for rugby union training to incorporate greater volume and specificity of skill demands (e.g., contested/opposed lineouts, scrums, rucking and kicking practice).

Despite evidence emphasising the importance of training specificity in improving performance [1,3], it should be expected that competitive matches include aspects that are different to training sessions. Attempts to precisely replicate match-play during training would likely both decrease skill acquisition and overgeneralise the complex multifactorial strategies of position-specific physical, psychological, technical and tactical development. Coaches are also reluctant to place athletes at further risk of injury during training sessions, particularly throughout in-season periods [24]. Although a balance between the risk (i.e., fatigue and injury) and reward (i.e., match performance) must be managed, the specificity of current rugby union training practices may be inadequate to elicit optimal training adaptations in a specific practice environment that align with the competitive match-play [3,7].

Training approaches could be developed that are centred on the integrative and concurrent development of necessary qualities. For example, previous recommendations of skill-based conditioning games and tactical metabolic conditioning scenarios can be periodised into training practices [28]. This affords the development of a combined tactical and technical approach within environments that imitate competitive matches. The use of modified games requires players to adapt to changing environmental and task constraints (i.e., the positioning of other players, ball positioning, opposition, referee, the wind, sunlight, etc.) [26,27] and make modifications to their decisions and consequent actions. Additional benefits may be seen while training in a fatigued state, as this has been shown to impair cognitive decision-making skills, and is effective in replicating match-play scenarios [5,29].

The development of practical solutions to both address the lack of representative match scenarios during training sessions, and to assuage injury risk concerns by coaches is clearly required [24]. The use of personal protective gear (body armour/padding) and a modification of the skill or situation could provide methods to prepare for these scenarios, and decrease potential injury risk.

While careful interpretation of the findings should be applied, alongside practical considerations, it is clear that improvements can be made to pre-professional rugby union training practices.

Practical Applications

Comparisons between competitive matches and training provide frameworks to develop specific training stimuli, which should efficiently and effectively prepare players for competitive demands. The current study findings indicate the specificity of current rugby union training practices may be inadequate to elicit optimal training adaptations in a specific practice environment that matches competitive demands [3,7]. Previous research identifying that successful teams win more lineouts on the oppositions throw and are effective at stealing the ball in rucking situations, may provide greater emphasis to these findings [17,18]. Coaches should attempt to provide position-specific training methodologies to prepare pre-professional rugby union players for competitive match demands. The authors acknowledge the study is limited by data from a single club and season. Future work attempting to assess the efficacy of traditional practice methods, including unopposed training against a constraints-based approach to training in multiple pre-professional rugby union players should be undertaken. This may provide a scientific framework for developing pre-professional players and improving insights into the relative importance of training specificity in contact sports.

Conclusion

This study provides the first insight into position-specific physiological, perceptual and key match event requirements of pre-professional rugby union training practices and competitive matches. The results emphasise the discrepancies between match demands and training sessions, particularly involving rucking, scrummaging, lineouts and kicking situations. There is clearly an apparent lack of specificity within on-field rugby union training sessions, which may potentially impede training attempts to maximise competitive performance. It is important however to consider the practicalities in replicating match demands during training sessions and the potential negative costs involved. Nonetheless, the results indicate current rugby union training strategies are sub-optimal in preparing players for competitive demands, and new strategies may need to be developed.

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References

1. Reilly T, Morris T, Whyte G. The specificity of training prescription and physiological assessment: A review. *J Sports Sci.* 2009;27(6):575-589.
2. Hartwig TB, Naughton G, Searl J. Motion analyses of adolescent rugby union players: a comparison of training and game demands. *J Strength Cond Res.* 2011;25(4):966-972.
3. Higham DG, Pyne DB, Anson JM, Hopkins WG, Eddy A. Comparison of activity profiles and physiological demands between international rugby sevens matches and training. *J Strength Cond Res.* 2016;30(5):1287-1294.
4. Tee JC, Lambert MI, Coopoo Y. GPS comparison of training activities and game demands of professional rugby union. *Int J Sports Sci Coach.* 2016;11(2):200-211.
5. Roberts SP, Trewartha G, Higgitt RJ, El-Abd J, Stokes KA. The physical demands of elite English rugby union. *J Sports Sci.* 2008;26(8):825-833.
6. Quarrie KL, Hopkins WG, Anthony MJ, Gill ND. Positional demands of international rugby union: Evaluation of player actions and movements. *J Sci Med Sport.* 2013;16(4):353-359.
7. Passos P, Araújo D, Davids K, Shuttleworth R. Manipulating constraints to train decision making in rugby union. *Int J Sports Sci Coach.* 2008;3(1):125-140.
8. Phillips E, Davids K, Renshaw I, Portus M. Expert performance in sport and the dynamics of talent development. *Sports Med.* 2010;40(4):271-283.
9. Pinder RA, Davids KW, Renshaw I, Araújo D. Representative learning design and functionality of research and practice in sport. *J Sport Exerc Psychol.* 2011;33(1):146-155.
10. Duthie GM. A framework for the physical development of elite rugby union players. *Int J Sports Physiol Performance.* 2006;1(1):2.
11. Jones MR, West DJ, Crewther BT, Cook CJ, Kilduff LP. Quantifying positional and temporal movement patterns in professional rugby union using global positioning system. *Eur J Sport Sci.* 2015;15(6):488-496.
12. Johnston RJ, Watsford ML, Kelly SJ, Pine MJ, Spurrs RW. Validity and interunit reliability of 10 Hz and 15 Hz GPS units for assessing athlete movement demands. *J Strength Cond Res.* 2014;28(6):1649-1655

13. Cunniffe B, Proctor W, Baker JS, Davies B. An evaluation of the physiological demands of elite rugby union using global positioning system tracking software. *J Strength Cond Res.* 2009;23(4):1195-1203.
14. Rampinini E, Coutts A, Castagna C, Sassi R, Impellizzeri F. Variation in top level soccer match performance. *Int J Sports Med.* 2007(28):1018-1024.
15. Portillo J, Abián P, Navia JA, Sánchez M, Abian-Vicen J. Movement patterns in under-19 rugby union players: Evaluation of physical demands by playing position. *Int J Perform Anal Sport.* 2014;14(3):934-945.
16. Foster C, Florhaug JA, Franklin J, et al. A new approach to monitoring exercise training. *J Strength Cond Res.* 2001;15(1):109-115.
17. Vaz L, Van Rooyen M, Sampaio J. Rugby game-related statistics that discriminate between winning and losing teams in IRB and Super twelve close games. *J Sports Sci Med.* 2010;9(1):51..
18. Jones NM, Mellalieu SD, James N. Team performance indicators as a function of winning and losing in rugby union. *Int J Perform Anal Sport.* 2004;4(1):61-71.
19. Cohen J. *Statistical power analysis for the behavioral sciences (rev.* Lawrence Erlbaum Associates, Inc; 1977.
20. Austin D, Gabbett T, Jenkins D. The physical demands of Super 14 rugby union. *J Sci Med Sport.* 2011;14(3):259-263.
21. Deutsch M, Kearney G, Rehrer N. Time–motion analysis of professional rugby union players during match-play. *J Sports Sci.* 2007;25(4):461-472.
22. Eaton C, George K. Position specific rehabilitation for rugby union players. Part I: Empirical movement analysis data. *Phys Ther Sport* . 2006;7(1):22-29.
23. Spencer M, Bishop D, Dawson B, Goodman C. Physiological and metabolic responses of repeated-sprint activities. *Sports Med.* 2005;35(12):1025-1044.
24. Dawson B, Hopkinson R, Appleby B, Stewart G, Roberts C. Comparison of training activities and game demands in the Australian Football League. *J Sci Med Sport.* 2004;7(3):292-301.
25. Renshaw I, Chow JY, Davids K, Hammond J. A constraints-led perspective to understanding skill acquisition and game play: A basis for integration of motor learning theory and physical education praxis? *Phys Educ Sport Pedagogy.* 2010;15(2):117-137.
26. Passos P, Cordovil R, Fernandes O, Barreiros J. Perceiving affordances in rugby union. *J Sports Sci.* 2012;30(11):1175-1182.
27. Pinder RA, Davids K, Renshaw I, Araújo D. Manipulating informational constraints shapes

movement reorganization in interceptive actions. *Atten Percept Psychophys.* 2011;73(4):1242-1254.
28. Gamble P. Periodization of Training for Team Sports Athletes. *Strength Cond J* . 2006;28(5):56-66.
29. Gabbett TJ. Skill-based conditioning games as an alternative to traditional conditioning for rugby league players. *J Strength Cond Res.* 2006;20(2):306-315.

Table Headings.

Table 1. Mean ± SD for backs and forwards of total distance, metres per minute, very high intensity activity, maximum speed, sprint count and sprints per minute for competitive matches and training sessions.

* Significant difference and large effect size compared to the match (*P* < 0.05; *d* > 0.80).

[a] Significant difference compared with outside backs (*P* < 0.05).

[b] Significant difference compared with centres (*P* < 0.05).

[c] Significant difference compared with halves (*P* < 0.05).

[d] Significant difference compared with loose forwards (*P* < 0.05).

[e] Significant difference compared with lock forwards (*P* < 0.05).

[1] Large effect size compared with outside backs (*d* > 0.80).

[2] Large effect size compared with centres (*d* > 0.80).

[3] Large effect size compared with halves (*d* > 0.80).

[4] Large effect size compared with loose forwards (*d* > 0.80).

[5] Large effect size compared with lock forwards (*d* > 0.80).

Table 2.

Notational Analysis (Mean ± SD) displayed in absolute and relative values during competitive matches and training sessions for backs.

* Significant difference and large effect size compared to the match (*P* < 0.05; *d* > 0.80).

[a] Significant difference compared with outside backs (*P* < 0.05).

[b] Significant difference compared with centres (*P* < 0.05).

[1] Large effect size compared with outside backs (*d* > 0.80).

[2] Large effect size compared with centres (*d* > 0.80).

Table 3. Notational Analysis (Mean ± SD) displayed in absolute and relative values during competitive matches and training sessions for forwards.

* Significant difference and large effect size compared to the match (*P* < 0.05; *d* > 0.80).

Figure Headings.

Figure 1. A comparison of competitive match and training session heart rate values.

* Significant difference and large effect size compared to the match ($P < 0.05$; $d > 0.80$).

Figure 2. A comparison of competitive match and training session sRPE values.

[a] Significant difference between matches and training sessions ($P < 0.05$).

[1] Large effect size between matches and training sessions ($d > 0.80$).

Table 1. Mean ± SD for backs and forwards of total distance, metres per minute, very high intensity activity, maximum speed, sprint count and sprints per minute for competitive matches and training sessions.

Position	Variable	Distance (m)	Total ($m \cdot min^{-1}$)	VHIA (m)	VHIA ($m \cdot min^{-1}$)	Max Speed ($km \cdot h^{-1}$)	Sprint Count (n)	Sprint ($m \cdot min^{-1}$)
Outside Backs	Match	6166 ± 929	70.8 ± 8.1	400 ± 170	4.5 ± 1.8	30.5 ± 2.4	21.8 ± 8.3	0.2 ± 0.09
	Training	4978 ± 1203*	59.7 ± 12.5	320 ± 202	3.8 ± 2.4	27.4 ± 1.8*	31.1 ± 17.9*	0.3 ± 0.20[1]
Centres	Match	5482 ± 1151[1]	64.0 ± 7.7	308 ± 152[1]	3.5 ± 1.5	28.4 ± 2.4[1]	28 ± 8.6[1]	0.3 ± 0.07
	Training	5217 ± 1208	59.7 ± 8.6	307 ± 173	3.4 ± 1.6	26.6 ± 1.4*	40.5 ± 15.5*	0.4 ± 0.17[2]
Halves	Match	5760 ± 885	66.2 ± 7.7	244 ± 110[a1]	2.7 ± 1.2	28.8 ± 2.2[1]	27.4 ± 8.3[1]	0.3 ± 0.09
	Training	5259 ± 1345	60.8 ± 12.3	227 ± 230	2.6 ± 3.0	26 ± 2.1*[a1]	42.8 ± 18.3*[a1,]	0.4 ± 0.19[3]
Loose-Forwards	Match	5457 ± 748[1]	62.0 ± 7.8	159 ± 124[a1,3]	1.8 ± 1.4	26.1 ± 3.2[a1,c3,2]	19.2 ± 8.5[b2,c3]	0.2 ± 0.09
	Training	4173 ± 1003*[a1,b2,c3]	48.4 ± 12.6*	129 ± 156[a1,b2]	1.4 ± 1.6	24.4 ± 2.0*[a1,b2,c3]	25.7 ± 19.4[b2,c3]	0.2 ± 0.22
Locks	Match	5278 ± 1250[1]	64.1 ± 6.2	159 ± 124[a1,b2,3]	1.9 ± 1.4	25.7 ± 2.8[a1,c3,2]	16.6 ± 7.9[b2,c3,1]	0.1 ± 0.08
	Training	4698 ± 1120	54.1 ± 14.9	211 ± 208	2.3 ± 2.1	24.8 ± 2.2[a1,b2]	33.8 ± 21.2*	0.3 ± 0.24[5]
Front Rows	Match	4885 ± 1272[a1,c3]	61.6 ± 8.7	78 ± 76.3[a1,b2,c3,4,5,]	0.9 ± 0.8	23.8 ± 3.2[a1,b2,c3,d4,5]	12.6 ± 6.9[a1,b2,c3,d4]	0.1 ± 0.07
	Training	4074 ± 974*[a1,b2,c3,5]	48.7 ± 12.4*	91.1 ± 80.2[a1,b2,c3,e5]	1.0 ± 0.9	23.3 ± 2.1[a1,b2,c3,d4.e5]	25.3 ± 19.2*[b2,c3]	0.2 ± 0.20[6]

* Significant difference and large effect size compared to the match ($P < 0.05$; $d > 0.80$).
[a] Significant difference compared with outside backs ($P < 0.05$).
[b] Significant difference compared with centres ($P < 0.05$).
[c] Significant difference compared with halves ($P < 0.05$).
[d] Significant difference compared with loose forwards ($P < 0.05$).
[e] Significant difference compared with lock forwards ($P < 0.05$).
[1] Large effect size compared with outside backs ($d > 0.80$).
[2] Large effect size compared with centres ($d > 0.80$).
[3] Large effect size compared with halves ($d > 0.80$).
[4] Large effect size compared with loose forwards ($d > 0.80$).
[5] Large effect size compared with lock forwards ($d > 0.80$).

Table 2. Notational Analysis (Mean ± SD) displayed in absolute and relative values during competitive matches and training sessions for backs.

Position	Outside Backs		Centres		Halves	
Variable	Match	Training	Match	Training	Match	Training
Tackles	1.5 ± 1.0	1.1 ± 1.5	5.7 ± 2.6[a1]	2.9 ± 3.1[*1]	4.5 ± 2.4[a1,b2]	1.8 ± 2.2[*]
Tackles·min^{-1}	0.01 ± 0.01	0.01 ± 0.01	0.06 ± 0.02	0.03 ± 0.04	0.05 ± 0.02	0.02 ± 0.02
Kicks	6.6 ± 8.2	0.3 ± 0.9[*]	0.2 ± 0.8[a1]	0.1 ± 0.4	1.1 ± 2.9[a1]	0.6 ± 1.1
Kicks·min^{-1}	0.07 ± 0.09	0.004 ± 0.01*	0.003 ± 0.01	0.001 ± 0.004	0.01 ± 0.03	0.006 ± 0.01
Kicks under pressure	1.1 ± 1.9	0.1 ± 0.4[*]	0.6 ± 0.7	0 ± 0[*1]	3.0 ± 2.4[a1,b2]	0.6 ± 1.1[*a1]
Kicks under pressure·min^{-1}	0.01 ± 0.02	0.001 ± 0.004	0.006 ± 0.007	0.001 ± 0.004*	0.03 ± 0.02	0.008 ± 0.01
Passes	3.3 ± 2.2	8.6 ± 8.4[*]	4.6 ± 2.4[1]	10.5 ± 10.0[*]	33.6 ± 15.2[a1,b2]	37.8 ± 20.6[a1,b2]
Passes·min^{-1}	0.03 ± 0.02	0.10 ± 0.08	0.05 ± 0.02	0.12 ± 0.11	0.39 ± 0.17	0.44 ± 0.23

* Significant difference and large effect size compared to the match ($P < 0.05$; $d > 0.80$).

[a] Significant difference compared with outside backs ($P < 0.05$).

[b] Significant difference compared with centres ($P < 0.05$).

[1] Large effect size compared with outside backs ($d > 0.80$).

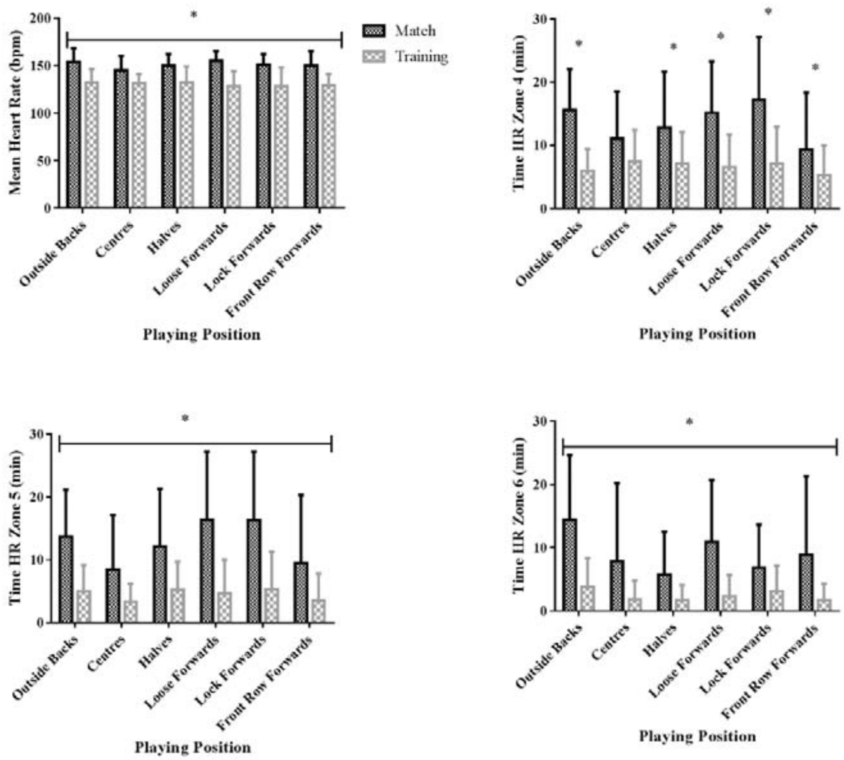
[2] Large effect size compared with centres ($d > 0.80$).

Table 3. Notational Analysis (Mean ± SD) displayed in absolute and relative values during competitive matches and training sessions for forwards.

Position	Loose Forwards		Locks Forwards		Front Row Forwards	
Variable	Match	Training	Match	Training	Match	Training
Tackles	7.2 ± 3.2[a1,b2]	2.4 ± 2.6*[1]	6.0 ± 2.9[a1,3]	2.4 ± 2.6*[1]	5.6 ± 3.0[a1]	1.7 ± 1.8*
Tackles·min^{-1}	0.08 ± 0.03	0.02 ± 0.04	0.07 ± 0.04	0.02 ± 0.02	0.07 ± 0.05	0.02 ± 0.02
Rucks	12.9 ± 4.2	1.3 ± 3.8*	15.0 ± 6.4	1.0 ± 4.1*	10.9 ± 4.5	1.2 ± 3.6*
Rucks·min^{-1}	0.14 ± 0.04	0.01 ± 0.04*	0.20 ± 0.12	0.01 ± 0.04*	0.15 ± 0.13	0.01 ± 0.03*
Mauls	3.1 ± 2.7	1.5 ± 3.0*	3.3 ± 3.0	1.9 ± 3.3	2.9 ± 2.6	1.8 ± 3.4
Mauls·min^{-1}	0.03 ± 0.03	0.01 ± 0.03	0.03 ± 0.03	0.02 ± 0.03	0.04 ± 0.04	0.02 ± 0.04
Scrums	23.4 ± 3.9	1.8 ± 3.4*	21.4 ± 7.2	1.6 ± 3.2*	21.7 ± 5.5	1.6 ± 3.2*
Scrums·min^{-1}	0.27 ± 0.06	0.02 ± 0.06*	0.28 ± 0.13	0.01 ± 0.03*	0.31 ± 0.21	0.01 ± 0.03*
Lineout Attack	12.7 ± 4.8	4.3 ± 5.9*	13.0 ± 5.1	4.1 ± 5.4*	12.2 ± 5.3	3.7 ± 5.3*
Lineout Attack.·min^{-1}	0.14 ± 0.05	0.05 ± 0.08*	0.16 ± 0.06	0.04 ± 0.06*	0.17 ± 0.13	0.04 ± 0.06*
Lineout Defence	11.6 ± 2.7	4.1 ± 6.2*	10.2 ± 4.3	3.9 ± 5.6*	10.7 ± 3.6	3.5 ± 5.7*
Lineout Defence·min^{-1}	0.13 ± 0.03	0.05 ± 0.08*	0.14 ± 0.09	0.04 ± 0.06	0.145± 0.07	0.04 ± 0.07*

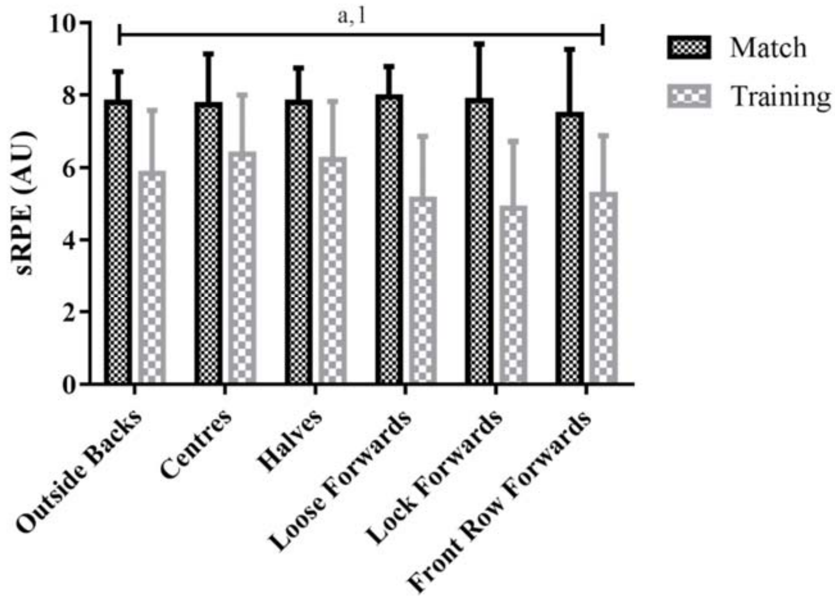
* Significant difference and large effect size compared to the match ($P < 0.05$; $d > 0.80$).
[a] Significant difference compared with outside backs ($P < 0.05$).
[b] Significant difference compared with centres ($P < 0.05$).
[c] Significant difference compared with halves ($P < 0.05$).
[1] Large effect size compared with outside backs ($d > 0.80$).
[2] Large effect size compared with centres ($d > 0.80$).
[3] Large effect size compared with halves ($d > 0.80$).
[4] Large effect size compared with loose forwards ($d > 0.80$).

Figure 1. A comparison of competitive match and training session heart rate values.



* Significant difference and large effect size compared to the match ($P < 0.05$; $d > 0.80$).

Figure 2. A comparison of competitive match and training session sRPE values.



[a] Significant difference between matches and training ($P < 0.05$).

[1] Large effect size between positions ($d > 0.80$).