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Senior Club-Level Rugby Union Player's Positional Movement Performance Using Individualized Velocity Thresholds and Accelerometer-Derived Impacts in Matches

Sohei Takamori,[1,2] Michael J. Hamlin,[1,3] David C. Kieser,[4] Doug King,[3,5,6] Patria Hume,[3,6,7] Tetsuya Yamazaki,[2] Masashi Hachiya,[2] and Peter D. Olsen[8]

[1]Department of Tourism, Sport and Society, Lincoln University, Christchurch, New Zealand; [2]Sports Medicine Center, Yokohama Minami Kyousai Hospital, Yokohama, Japan; [3]Faculty of Health and Environmental Science, Sports Performance Research Institute New Zealand (SPRINZ), Auckland University of Technology, Auckland, New Zealand; [4]Department of Orthopaedic Surgery and Musculoskeletal Medicine, University of Otago, Christchurch, New Zealand; [5]School of Science and Technology, University of New England, Armidale, New South Wales, Australia; [6]Traumatic Brain Injury Network (TBIN), Auckland University of Technology, Auckland, New Zealand; [7]National Institute for Stroke and Applied Neurosciences (NISAN), Auckland University of Technology, Auckland, New Zealand; and [8]Department of Nursing, Midwifery and Allied Health, Ara Institute of Canterbury, Christchurch, New Zealand

Abstract

Takamori, S, Hamlin, MJ, Kieser, DC, King, D, Hume, P, Yamazaki, T, Hachiya, M, and Olsen, PD. Senior club-level rugby union player's positional movement performance using individualized velocity thresholds and accelerometer-derived impacts in matches. *J Strength Cond Res* 36(3): 710–716, 2022—Game demands of professional rugby union players have been well documented; however, there is minimal game demand information using individualized velocity thresholds and collision loads, particularly for amateurs. This study investigated movement patterns of 20 male amateur rugby players during 16 senior premier division one matches using global positioning system (GPS) devices sampling at 10 Hz. Derived GPS variables included distances, velocities, sprinting, and impacts. Data files from 86 player games (≥60 minutes of play per game) were categorized into broad (forwards and backs) and specific (front row, second row, back row, half back, inside back, and outside back) positional groups for analysis. It was most likely that backs covered more distance in the high-speed running (>60% maximal velocity) zone (502 ± 157 m) compared with forwards (238 ± 147 m) (100/0/0%, chances of positive/trivial/negative differences, effect size [ES] = 1.3), performed more striding (backs 1,116 ± 240, forwards 954 ± 240 m, 96/4/0%, ES = 0.5), and sprinting (backs 121 ± 58, forwards 90 ± 65 m, 93/7/0%, ES = 0.5). However, forwards had higher collision loads (35 ± 12 arbitrary units) compared with backs (20 ± 6, 99.9/0.1/0%, ES = 1.3) with back row forwards completing the highest collision load of any playing position (40 ± 13). Our example match movement performance and impact information is valuable to coaches and support staff in preparing player profiles for similar-level rugby players to help manage their workloads.

Key Words: GPS technology, game analysis, collision, conditioning, distance, sprint

Introduction

Rugby union is a complex collision team sport that is played by 15 players from 2 teams over two 40-minute halves. As with many team sports, rugby union is an intermittent game with long periods of lower intensity walking and jogging interspersed with shorter periods of higher intensity running and sprinting. In addition, high-impact collisions along with static exertions and other movements are also required to enable participation. Depending on the playing position, players require certain physical attributes combined with specific positional skill sets and movement abilities to successfully complete their job during match activities (6,15,39).

Since the introduction of professionalism of rugby union in 1995, a great deal of research has been conducted to better understand the movement characteristics and workloads of players (16–18). Studies have reported on work:rest ratios (30,34), endocrine responses (12,13), time-motion analysis (37), and, more recently, the movement demands of players in rugby union (15). However, due to demand on time and the associated costs required to complete time-motion analysis of rugby union match play (39), this has largely given way to the more objective and relatively less expensive global positioning systems (GPS) technology (10,11).

Using GPS technology, a number of studies have used speed categories based on arbitrary absolute speeds to characterize player movement demands during a rugby match (9,14). However, using standardized speed thresholds in this way does not account for individual differences in speed between players and positions. Therefore, using such absolute speed thresholds can misrepresent individual player's movement characteristics and has resulted in some authors moving away from absolute speeds to using individualized player speeds (based on maximum sprint speeds during match play) (7,42). Having individualized data on player speeds is advantageous for strength and conditioning

Address correspondence to Michael J. Hamlin, mike.hamlin@lincoln.ac.nz.

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personnel because it can enhance training specificity and improve monitoring accuracy of individual athletes.

When considering game demands of rugby union players, knowledge of movement patterns is important, but other factors such as time spent in static contractions (mauling and scrummaging) (39) and impacts from collisions (24) can affect overall performance and should be considered when preparing players for competition. For example, impacts produce greater physical (increased neuromuscular fatigue and muscle damage) and mental (increased perceived exertion) stress (26), which can subsequently influence performance. Knowing the total amount of training stress (including running, impacts, resistance training, etc.) allows for a more precise training prescription and recovery loading for players. Although static (isometric) movement patterns are difficult to measure, impact collisions sustained while playing rugby union have recently been reported (29,42) using inertial measurement componentry within GPS units and may prove useful when prescribing training and recovery loads for players.

The increased research focus on professional rugby union players has developed useful physiological and movement profiles of elite professional rugby union players (31). However, these elite players only make up a small proportion of the rugby union playing population, with a much larger percentage being amateur club players. Elite players have superior skill levels, are generally heavier, have higher muscular strength, better endurance, and power when compared with nonelite amateur rugby union players (38). This suggests that the fitness levels, and therefore match movement patterns and collision impact loads, are probably quite different when comparing the 2 groups of players. Therefore, the aim of this study was to investigate the movement patterns and collision impact loads of a nonelite amateur senior premier-level rugby union team over the season to develop movement profiles that may then be used by coaches and strength and conditioning personnel to assist with training and development.

Methods

Experimental Approach to the Problem

We used a longitudinal cross-sectional study design to examine the movement patterns of relatively unresearched amateur senior premier club-level rugby union players over one competitive season in Christchurch, New Zealand. The players were separated by playing positions to establish differences between players in different positions. We have chosen performance variables typically used in previous studies including maximal velocity, velocity at common thresholds, running distances, and impact measures, which we believe give accurate measures of rugby player performance.

Subjects

Twenty amateur club-level rugby union players (age 21.4 ± 2.0 [range 19.1–26.2] years, height 184.5 ± 7.6 cm, body mass 97.1 ± 12.3 kg, mean ± *SD*) provided GPS files from 16 senior premier division one matches between March and August of the 2017 season. The study had Lincoln University Human Ethics Committee's approval (reference 2017-04), and subjects were informed of the benefits and risks of the investigation before signing an institutionally approved informed consent document to participate in the study.

Procedures

Global Positioning System Equipment. Individualized GPS units (Viper pod 2; STATSports, Belfast, United Kingdom) placed inside a tight-fitting protective vest were given to players on each match day. The GPS units were turned on approximately 10 minutes before the game, and the vest was then positioned between the scapulae of players. Each player wore the same GPS unit for all matches. Each GPS device contains a GPS sensor (10 Hz), a 3-D accelerometer (100 Hz), 3-D gyroscope, and a 3-D digital compass. After each match, GPS data were downloaded using the manufacturer's software package (Viper PSA software; STATSports) and subsequently clipped (to include match play data only) for further analysis. Previous research indicates the 10-Hz STATSports Viper model is a valid and reliable tool for measurement of peak speed and distance covered (3). All players were familiarized with the devices as part of their normal training and playing practices. A minimum of 60 minutes of match play was required for data files to be included for analysis (36), resulting in 86 data files.

Global Positioning System Movement Variables. The derived GPS variables were distances covered, movement velocities, number of sprints, and collision load during matches. The total distance (m) was calculated for each data file along with the maximum speed (Vmax) and number of sprints (number of times Vmax >81% lasting more than 1 second). The data files were separated into 5 speed zones similar to Cahill et al. (7), which were based on each player's individual running speed (Vmax) attained using the GPS devices from any game played throughout the 2017 competitive season. These zones were <20% Vmax (standing and walking), 20–50% Vmax (jogging), 51–80% Vmax (striding), 81–95% Vmax (sprinting), and 96–100% Vmax (maximum sprinting). To compare high-speed running results with previous research, we also calculated high-speed running (>60% Vmax). Along with the absolute distance (m) spent in each of these zones, we also calculated the relative distance spent in each zone (distance spent in zone/total match distance × 100).

Collision Variables. Data files were also analyzed for collision events through the 100-Hz accelerometer using an algorithm in the STATSports Viper Rugby software, which takes into consideration speed, duration, and magnitude of impact and produces a collision load score. Previous research showed a high correlation between events identified as collisions from the STATSports software and video analysis (0.96) (33). For the collision load score calculation, collisions were detected by the software as a change in the orientation of the athletes axis and an impact of >8 g. Once this occurred, a weighted algorithm within the STATSports software combined maximum velocity during the collision, peak force, and the collision duration to produce the collision load (33). In this way, the collision load is an attempt to quantify the overall load that occurs in complex collision movements that occur in sports such as rugby. In addition, using just the accelerometer data in the X, Y, and Z axis, the software also calculated the number of impacts at various g-force loads. Based on previous studies (14,35) and the manufacturer's software, the intensity of collisions can be graded using the following scale: 3–10 g, moderate to heavy impact (collision with ground, rucking); 10–15 g, very heavy impact (tackle collision); and 15–66 g, severe impact (high speed/force collision).

Player Positions. To examine the differences in movement patterns between playing positions, the data files were categorized broadly into forwards (hooker, prop, lock, loose forwards, and number-8) and backs (half back, first 5, second 5, center, wing, and fullback). Similar to previous research (7), we also categorized the players into more specific playing positions to account for their unique roles within the team including front row (15 prop/hooker), second row (11 lock), back row (26, flanker/number-8), half back (n = 8), inside backs (22 first 5/second 5/center), and outside backs (4, wing/fullback).

Statistical Analyses

Changes in the mean of the variables and *SD*s representing the between- and within-subject variability were estimated using a mixed-modeling procedure (Proc Mixed) in the Statistical Analysis System (Version 9.3, SAS Institute, Cary, NC). The differences in GPS-derived variables were compared between groups, and Cohen's value of 0.2 of the between-subject *SD* was used to assess the smallest worthwhile change (8). All data were assessed using the magnitude-based inferences (2). For clear results, the magnitude of the change was reported using the following scale <0.5% = most unlikely; 0.5–5% = very unlikely; 5–25% = unlikely; 25–75% = possibly; 75–95% = likely, 95–99.5% = very likely, and >99.5% = most likely (23). The direction of the change (increased, trivial, or decreased) was determined and interpreted according to the variable. We also calculated the effect size statistics (ES, Cohen's d) from the change in the mean between groups divided by the between-subject *SD*. The magnitude of the ES was interpreted using Hopkins et al. (23) descriptors (i.e., 0.2 small, 0.6 moderate, 1.2 large, and 2.0 very large). This study used a convenience sample of 20 players producing 86 player-game data sets over one rugby season.

Results

Each player provided on average 4.3 ± 2.9 data files over the duration of the study to enable match movements to be quantified. Analyses showed that there were substantial differences between player positions for distances covered, movement velocities, number of sprints, and collision load during matches.

Player Movement Velocities

The absolute speeds for Vmax and the various threshold speed ranges are shown in Table 1. The overall average Vmax speed was most likely slower (99.9/0.1/0%, chances of positive/trivial/negative differences in Vmax; ES = 1.2) in forwards (26.7 ± 2.8 km·h^{-1}) compared with backs (30.3 ± 1.8 km·h^{-1}). In particular, inside and outside backs, along with half backs, demonstrated the highest Vmax speeds when compared with the front, second, or back row forwards. Because speed zones were calculated from Vmax data, the subsequent speed zone thresholds for backs were higher than for forwards.

Player Distances Covered

Comparisons of absolute and relative distances covered in matches between playing positions are shown in Tables 2 and 3, respectively. The absolute distance covered in a match was most likely lower (99.9/0.1/0%, ES = 1.0) in forwards (5,063 ± 851 m) compared with backs (5,977 ± 916 m). Although backs most likely covered more distance in the higher intensity striding and sprinting speed zones, they also completed more distance in the standing/walking intensity speed zones. In addition, backs most likely covered more ground per minute (76.1 ± 4.6 m·min^{-1}), when compared with forwards (66.1 ± 4.1 m·min^{-1}, 100/00/0%, ES = 1.5).

Outside backs typically covered the most distance in the standing/walking speed zone (Table 3) but completed more maximal sprinting (0.3 ± 0.1% of total distance spent in this speed zone). Half backs had the highest proportion of distance completed in the striding speed zone. Backs (half back, inside back, and outside back) had the highest proportion of distance completed in the high-speed zone (i.e., > 60% Vmax), and outside backs had the highest proportion of distance at maximal sprinting (i.e., 96–100% Vmax).

Player Number of Sprints

Using the relative speeds for sprints (Vmax ≥81% lasting more than 1 second), forwards completed as many sprints as backs in the games (Table 2). Outside backs completed the highest number of sprints (11 ± 3 per game), but this was not significantly different from other playing positions.

Player Collision Load

Overall forwards were most likely involved in higher collision loads than backs (99.9/0.1/0%, ES = 1.3). A greater collision load was detected for the back row forwards (40 ± 13) when compared with all other playing positions (Table 4). Outside backs recorded the lowest collision load, but the collisions they were involved in registered the highest impact forces.

Table 1
Maximal running speed (km·h^{-1}) and speed-zone thresholds (km·h^{-1}) in different playing positions in senior amateur premier-level rugby union players.*

	n	Vmax	Stand/walk	Jog	Striding	Sprinting	Maximal sprinting	HSR
Forwards	52	26.7 ± 2.8	<5.3	5.3–13.4	13.5–21.4	21.5–25.4	>25.4	>16.0
Backs	34	30.3 ± 1.8^{z}	<6.1	6.1–15.2	15.3–24.3	24.4–28.1	>28.1	>18.2
Front row	15	24.5 ± 2.4^{b,c,d,e,f}	<4.9	4.9–12.2	12.3–19.6	19.7–23.3	>23.3	>14.7
Second row	11	27.7 ± 2.6^{a,e,f}	<5.6	5.6–13.9	14.0–22.2	22.3–26.4	>26.4	>16.6
Back row	26	27.5 ± 2.6^{a,e,f}	<5.5	5.5–13.8	13.9–22.0	22.1–26.1	>26.1	>16.5
Half back	8	29.3 ± 1.4^{a}	<5.9	5.9–14.7	14.8–23.4	23.5–27.8	>27.8	>17.6
Inside back	22	30.6 ± 2.0^{a,b,c}	<6.1	6.1–15.3	15.4–24.5	24.6–29.1	>29.1	>18.4
Outside back	4	30.9 ± 1.1^{a,b,c}	<6.2	6.2–15.5	15.6–24.7	24.8–29.3	>29.3	>18.5

*Data are the average maximal running velocity (Vmax) ± *SD* and speed-zone thresholds in km·h^{-1} for the specific rugby playing positions. Stand/walk = <20% Vmax; Jog = 20–50% Vmax; striding = 51–80% Vmax; sprinting = 81–95% Vmax; maximal sprinting = 96–100% Vmax; HSR = high-speed running >60% Vmax. All superscript letters indicate a clear and at least "likely" (75–95% probability) substantial change between positional groups for Vmax data only. [z]Substantial difference between forwards and backs; Substantial difference compared with [a]front row, [b]second row, [c]back row, [d]half back, [e]inside back, [f]outside back.

Table 2

Total time and distance covered within each speed zone along with the total number of sprints in different playing positions in senior amateur premier-level rugby union players.*

	Time (min)	Total ($m\cdot min^{-1}$)	Total (m)	Stand/walk (m)	Jog (m)	Striding (m)	Sprinting (m)	Maximal Sprinting (m)	HSR (m)	Sprints (#)
Forwards	77 ± 12	66.1 ± 4.1	5,063 ± 851	2,055 ± 384	2,409 ± 519	954 ± 325	90 ± 65	8 ± 7	238 ± 147	7 ± 5
Backs	79 ± 11	76.1 ± 4.6^{z}	5,977 ± 916^{z}	2,493 ± 526^{z}	2,512 ± 438	1,116 ± 240^{z}	121 ± 58^{z}	11 ± 8	502 ± 157^{z}	9 ± 4
Front row	75 ± 13	66.8 ± 4.3^{d,e,f}	5,008 ± 871^{e,f}	1,914 ± 452^{e,f}	2,642 ± 552	964 ± 354^{d}	80 ± 53^{f}	11 ± 10^{f}	173 ± 100^{c,d,e,f}	7 ± 4
Second row	80 ± 10	66.8 ± 4.2^{d,e,f}	5,305 ± 761^{e,f}	2,103 ± 368^{e,f}	2,580 ± 342	912 ± 257^{d}	78 ± 52^{f}	7 ± 6^{f}	227 ± 64^{d,e,f}	7 ± 5
Back row	76 ± 12	65.5 ± 4.0^{d,e,f}	4,992 ± 888^{e,f}	2,116 ± 340^{e,f}	2,203 ± 493^{a,b,e}	965 ± 344^{d}	101 ± 76^{f}	7 ± 6^{f}	281 ± 180^{a,d,e,f}	8 ± 6
Half back	72 ± 7^{f}	77.8 ± 4.8^{a,b,c}	5,598 ± 725	1,990 ± 240^{e,f}	2,514 ± 389	1,368 ± 237^{a,b,c,e,f}	126 ± 47	9 ± 2^{f}	536 ± 170^{a,b,c}	9 ± 3
Inside back	79 ± 12	75.8 ± 4.8^{a,b,c}	6,024 ± 1,008^{a,b,c}	2,552 ± 476^{a,b,c,d,f}	2,525 ± 481^{c}	1,057 ± 193^{d}	112 ± 6	11 ± 8^{f}	491 ± 154^{a,b,c}	8 ± 5
Outside back	87 ± 4	74.3 ± 2.7^{a,b,c}	6,478 ± 384^{a,b,c}	3,172 ± 67^{a,b,c,d,e}	2,432 ± 356	936 ± 72^{d}	166 ± 57^{a,b,c}	20 ± 9^{a,b,c,d,e}	493 ± 185^{a,b,c}	11 ± 3

*Data are mean ± *SD*. Stand/walk = <20% Vmax; Jog = 20–50% Vmax; striding = 51–80% Vmax; sprinting = 81–95% Vmax; maximal sprinting = 96–100% Vmax; HSR = high-speed running >60% Vmax; sprints = number of times Vmax ≥81% lasting more than 1 second. All superscript letters indicate a clear and at least "likely" (75–95% probability) substantial change between positional groups. ^{z}Substantial difference between forwards and backs; Substantial difference compared with ^{a}front row, ^{b}second row, ^{c}back row, ^{d}half back, ^{e}inside back, ^{f}outside back.

Discussion

The aim of the current study was to investigate movement patterns and collision impact loads of amateur rugby union players, so that better informed decisions could be made by coaching staff around training loads and recovery. We found absolute and relative walking and running distances differed considerably between broad (backs versus forwards) and specific (front row, second row, back row, half back, inside back, and outside back) playing groups. Similarly, collision loads also differed between playing positions with forwards having a substantially higher collision load compared with backs. Such information may help improve training effectiveness in amateur rugby union players.

Effectively capturing the diverse range of movements that occur in individuals in field sports is a complicated and difficult task, which has been expedited somewhat by the introduction of GPS and microtechnology. However, new technology is only as good as the knowledge required to understand such technology. This study has used a relatively new reporting technique to characterize movement patterns in rugby players. Rather than using traditional arbitrary absolute speeds for various thresholds, which do not account for differences in speed between players, we have used individualized player speeds to calculate individualized player speed thresholds. By using this technique, we found substantial differences between speed zones for player positions (Table 1), but more importantly, we have produced speed ranges that can be used to more accurately determine position-specific strength and conditioning goals.

Rugby is a contact sport in which a number of impacts can occur resulting in muscle damage, which may initiate an acute inflammatory response (32), considerable muscle soreness (19), and attenuated neuromuscular function (35). Monitoring collision loads in rugby, which can result from contact events such as tackling, scrummaging, mauling, running into contact, and contact with the ground (40,41), are therefore important when considering subsequent training and recovery strategies. The high physical demands of rugby result in high player match loads (14,27), and if subsequent recovery is not sufficient, injury and illness may ensue (21). Our data showed a substantial difference in the collision loads between rugby playing positions. Overall, forwards had a substantially higher collision load than backs (Table 4), but more specifically, back row forwards (flankers and number-8) had the highest collision load of all players including other forwards. Given that the role of back row forwards includes frontline defense, a high collision load is to be expected. It was interesting to note that while outside backs had the lowest overall contact load, they did have the highest average impact intensities suggesting that the lower number of collisions they make are usually high-force contacts. However, collision loads only make up a proportion of overall player load (which is made up of not only collisions but all forces exerted on the body during the match in all 3 axes; mediolateral, anteroposterior, and vertical). Recent work suggests that backs, particularly inside backs, accumulate notably higher player loads when compared with forwards (29). Further work is required to understand the total player load calculation in contact sports such as rugby (i.e., contact loads, acceleration and deceleration loads, running loads, and static loads), which will enable a more holistic approach to be taken to planning and adjusting overall player loading and recovery.

Although there is a plethora of information on movement patterns of professional rugby players, such information is lacking on nonelite amateur players that make up most registered rugby union players in most countries. In the current study, we found that nonelite amateur premier level rugby union backs

Table 3

Relative distance covered (%) within each speed zone in different playing positions in senior amateur premier-level rugby union players.*

	Stand/walk	Jog	Striding	Sprinting	Maximal sprinting	HSR
Forwards	40.7 ± 5.6	47.4 ± 5.3	18.7 ± 5.4	1.8 ± 1.3	0.1 ± 0.1	4.7 ± 2.8
Backs	41.7 ± 4.5	42.0 ± 3.5[z]	18.5 ± 3.9	2.0 ± 1.0	0.2 ± 0.1	8.4 ± 2.6[z]
Front row	37.9 ± 5.9[c,e,f]	52.7 ± 5.1[b,c,d,e,f]	19.1 ± 6.2[b,c,d,e,f]	1.6 ± 0.9	0.2 ± 0.2	3.6 ± 2.3[c,d,e,f]
Second row	39.6 ± 4.2[c,f]	48.8 ± 2.6[a,c,d,e,f]	17.5 ± 3.7[a,c,d,e,f]	1.5 ± 1.0	0.1 ± 0.1[f]	4.5 ± 1.6[d,e,f]
Back row	42.8 ± 5.2[a,b,d,f]	43.8 ± 3.1[a,b,e,f]	18.9 ± 5.7[a,b,e,f]	2.0 ± 1.5	0.1 ± 0.1[f]	5.5 ± 3.3[a,d,e]
Half back	35.9 ± 1.7[c,e,f]	44.9 ± 3.2[a,b,e,f]	22.9 ± 2.6[a,b,e,f]	2.1 ± 0.7	0.1 ± 0.0[f]	9.3 ± 2.2[a,b,c]
Inside back	42.5 ± 2.6[a,d,f]	41.9 ± 2.6[a,b,c,d,f]	17.6 ± 3.3[a,b,c,d,f]	1.9 ± 1.2	0.2 ± 0.1	8.3 ± 2.8[a,b,c]
Outside back	49.1 ± 1.8[a,b,c,d,e]	37.5 ± 4.0[a,b,c,d,e]	14.4 ± 0.4[a,b,c,d,e]	2.5 ± 0.8	0.3 ± 0.1[bcd]	7.6 ± 3.0[a,b]

*Data are mean ± *SD*. Stand/walk = <20% Vmax; Jog = 20–50% Vmax; striding = 51–80% Vmax; sprinting = 81–95% Vmax; maximal sprinting = 96–100% Vmax; HSR = high-speed running >60% Vmax. All superscript letters indicate a clear and at least "likely" (75–95% probability) substantial change between positional groups. [z]Substantial difference between forwards and backs; Substantial difference compared with [a]front row, [b]second row, [c]back row, [d]half back, [e]inside back, [f]outside back.

covered 5,977 m during a typical game, whereas forwards covered substantially less (5,063 m). These absolute distances covered by the nonelite amateur rugby players in this study are notably less than the distances reported for professional English premiership players in the United Kingdom (backs 6,545 m and forwards 5,850 m) (7), (backs 7,227 m and forwards 6,680 m) (14), or international players (backs 7,002 m and forwards 6,427 m) (9) using 1- or 5-Hz GPS recording frequency. However, our data were in accordance with a recent study on professional rugby union players that used 10-Hz GPS recording frequencies (27) along with the only other study investigating amateur senior premier level rugby players (backs 5,377 m and forwards 4,260 m) (29). Differences between studies may be related to differences in research methodologies including subject numbers involved. For example, in 2 of the previous studies only 2 subjects were involved in the research (1 back and 1 forward) (9,14) increasing the risk of bias that accompanies low subject numbers. Absolute distances can also be affected by the players match time. While the average time spent playing in the rugby matches were relatively high for our group (72–87 minutes), some players did not play the whole match. One way to account for this is to use the amount of ground covered per minute, which was 66.1 $m \cdot min^{-1}$ for forwards and 76.1 $m \cdot min^{-1}$ for backs in the players of this study that is much closer if not higher than previously reported data in professional (forwards 64–67 $m \cdot min^{-1}$ and backs 71–72 $m \cdot min^{-1}$) (7,14) and amateur players (forwards 55.7 $m \cdot min^{-1}$ and backs 68.5 $m \cdot min^{-1}$) (29).

In accordance with previous research (37), our data showed that movement demands varied with different rugby union playing positions. For example, all forwards covered a similar total amount of ground during matches (4,992–5,305 m, Table 2), but front row forwards spent a greater proportion of their time jogging (52.7%) when compared with second or back row forwards (48.8 and 43.8% respectively) and all backs (Table 3). Backs, in particular half backs, spent a greater proportion of their time striding compared with forwards, whereas outside backs spent the most time maximal sprinting (Table 3). Similarly, backs spent a greater proportion of their time in high-speed running (>60% Vmax), when compared with front and second row forwards. These results indicate forwards completed less running (apart from jogging) when compared with backs, which some researchers have suggested might be due to forwards performing more high-intensity exercise in the form of static work such as tackling, scrimmaging, and rucking (1,39). However, in a recent study that used microtechnology (OptimEye S5 device; Catapult Innovations, Melbourne, Australia) in the form of a triaxial accelerometer sampling at 100 Hz, on a similar rugby cohort to this study (amateur premier-level rugby players), the slow player load component of the accelerometer data (which is believed to be a useful proxy for low-speed exertions such as rucking and scrummaging) was also significantly lower in forwards when compared with backs (29). It may be that in professional rugby games, the forwards have different playing strategies compared with players in amateur games that might account for differences in player workloads. Improvement in the ability of wearable devices to incorporate hardware/software that can easily calculate all forms of physical exertion (including static contractions) will ultimately enable researchers to accurately calculate total workloads in all players.

Match movement demands in field-based sports such as rugby are complicated and can combine irregular, multidirectional, high-, and low-intensity efforts, which can be influenced by a number of factors including weather (28), level of opposition

Table 4

Collision load and impacts during rugby union match play in senior amateur premier-level rugby union players.*

		Impact intensity		
	Collision load (arbitrary units)	3–10 g	10–15 g	15–66 g
Forwards	35 ± 12	3,056 ± 652	140 ± 87	51 ± 29
Backs	20 ± 6[z]	3,177 ± 584	133 ± 129	58 ± 60
Front row	28 ± 9[c,d,f]	3,067 ± 721	63 ± 36[f]	28 ± 17[f]
Second row	31 ± 8[c,d,e,f]	3,183 ± 504	195 ± 88[a,e]	65 ± 28[a]
Back row	40 ± 13[a,b,d,e,f]	2,996 ± 681	162 ± 78[a]	59 ± 28[a]
Half back	18 ± 2[a,b,c]	3,391 ± 511	126 ± 191	58 ± 76
Inside back	23 ± 7[b,c]	3,042 ± 568	119 ± 108[b,f]	51 ± 53[f]
Outside back	13 ± 3[a,b,c]	3,492 ± 708	221 ± 79[a,e]	99 ± 56[a,e]

*Data are mean ± *SD*. Collison load; cumulated load score for match collisions calculated from the Statsport algorithm, impact intensity; number of impacts for each impact force zone. All superscript letters indicate a clear and at least "likely" (75–95% probability) substantial change between positional groups. [z]Substantial difference between forwards and backs; Substantial difference compared with [a]front row, [b]second row, [c]back row, [d]half back, [e]inside back, [f]outside back.

(20), substitution of players (4), if played at home or away, and level of player's fitness (28).

Therefore, caution needs to be taken when using GPS and microtechnology data (e.g., distances and impacts) in isolation of these other important factors. In addition, match movements made by individuals in field-based team sports are also influenced by other contextual factors such as tactical decisions and technical proficiency of players (5). Not knowing this other contextual information is a limitation of this study, and future studies should look to incorporate such information where possible to increase the depth of knowledge on match movement patterns. This study also did not investigate movement parameters such as acceleration and deceleration, which have been shown to increase with level of competition in rugby sevens matches (22).

To maximize training benefit through specificity, strength and conditioning professionals require accurate and individualized data on their players. Individualized data allow for a tighter targeting of training parameters including recovery that should result in greater efficiency and effectiveness of training. Research consistently indicates players given individualized strength and conditioning programs produce greater performance improvements (25). Therefore, data used to assist in prescribing training and recovery loads need to account for the individual rather than for the team. Using such individualized data from GPS and other devices will increase training impact and reduce resource wastage.

Using the data collected in our study, coaches and support staff will be able to develop specific training programs to prepare rugby athletes for premier division amateur matches as well as allowing for sufficient postgame recovery. For example, half backs should be sufficiently prepared to be able to complete approximately 6,000 m of activity during a game including approximately 1,000 m of striding (51–80% Vmax), 500 m of high-speed running (>60% Vmax), and 126 m of sprinting (81–95% Vmax). A front row forward should be able to complete at least 5,000 m of activity including 2,500-m jogging (20–50% Vmax), over 900 m of striding, 173 m of high-speed running, and 80 m of sprinting.

In conclusion, this study has investigated the use of individualized speed zones and accelerometer-derived collision loads for amateur rugby union players. We have found that forwards had higher collision loads compared with backs, but backs spent a greater amount of time striding compared with forwards. Outside backs completed the most time maximal sprinting. Such information is important when prescribing training for amateur-level rugby union players.

Practical Applications

Example match movement performance along with collision and impact information is valuable to coaches and support staff in preparing player profiles for similar-level rugby players to help manage their workloads. The information provided in our study can be used to prepare similar-level athletes in the varied rugby player positions using appropriate training methods. To avoid underpreparing players and to take into consideration the variation between matches, we recommend that strength and conditioning trainers aim to have players strive for the 95th percentile of our results. For example, a forward should be able to jog at least 3,447 m (mean + 2 *SD*, from Table 2).

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