Differences and Changes in the Physical Characteristics of Professional and Amateur Rugby Union Players

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Abstract

Smart, DJ, Hopkins, WG, and Gill, ND. Differences and changes in the physical characteristics of professional and amateur rugby union players. *J Strength Cond Res* 27(11): 3033–3044, 2013 –Numerous studies have highlighted differences between playing levels and positions in rugby union; however, few studies have investigated longitudinal progressions of body composition and physical performance. Between-player differences and within-player changes in body composition, strength, power, speed, and repeated sprint ability, from 1,161 New Zealand rugby union players from 2004 to 2007, were estimated using a mixed modeling procedure. Props had the highest mass, percent body fat, strength, and slowest speed times compared with the other positions, whereas outside backs had the fastest speed time and lowest percent body fat. For most measures, there were small-to-moderate differences (range, 1.1–14%) between players selected and not selected for provincial teams and small-to-large differences (range, 1.8–15%) between provincial and Super Rugby (professional) players. The faster 20-m sprint times in international compared with Super Rugby players was small in magnitude for both the forwards (1.9%) and backs (2.2%). The average annual improvements were small to moderate for strength (range, 2.1–15%) and small for repeated sprint ability within the lower playing levels (~1.5%). Small increases occurred in lower body strength (~7.0%) as players moved from Super Rugby to provincial competition. Small decreases in sprint time (~1.6%) and small increases in strength (~6.3%) occurred as players moved from Super Rugby to mid-year international competition. The differences between levels in performance provide level-specific characteristics from Super Rugby and below, but international players may be selected because of greater skill and experience. Changes in physical performance between competitions may be a result of reduced training loads because of regular high-intensity matches and greater travel involved in the Super Rugby competition.

Key Words body composition, strength, speed, repeated sprint ability, mixed model

Introduction

Rugby union is a field-based team sport that requires a diverse range of physical attributes to tolerate a large amount of physical contact and numerous maximal sprints (12). Since the introduction of professionalism in 1995, the characteristics of speed, strength, power, and body composition of players has evolved rapidly, and as a consequence, the speed and physicality of matches has increased (12,35). The measurement of players' physical characteristics has highlighted position-specific attributes. Forwards are involved in more rucks, mauls, line outs, and scrums, which requires greater mass, height, strength, and power to be successful (9,11). In contrast, the backs primary role in beating the opposition in open play requires a combination of speed, acceleration, and agility (12,28,29). Differences between playing levels have also been reported. For example, senior club players possess greater height, mass, speed, strength, and aerobic fitness compared with their lower-level age group counterparts (29).

Few longitudinal studies exist exploring the progression of individual's and teams' physical characteristics. Olds (26) used historical data to track the evolution of physique in male rugby union players from 1905 to 1999. It was shown that the body mass index had increased at a rate of 3–4 times faster in rugby union players during the last 25 years compared with the rest of the century. In addition, a more recent study showed rapid increases in mass (~10%) since the inception of the professional era (30).

To track more specific individual player changes, Duthie et al. (11) modeled the fat-free mass of professional Super Rugby players over a period of 5 years, which included the Super Rugby (the Southern Hemisphere premier professional competition played across Australia, New Zealand and South Africa) and regional club competitions at different times of the year. It was reported that there was a decrease in the proportion of the fat-free mass of players that occurred

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primarily during the club competition. More recently, Argus et al. (2) tracked the changes in strength and power over the period of a Super Rugby season, reporting small increases (8.5%) in box squat 1 repetition maximum (1RM) and small decreases (3.4%) in jump squat peak power.

Traditionally, athletes undergo fitness assessments that are used to determine the current level of fitness, motivate individuals, and to assist in future program prescription. Typically, these test data are used for the short term to evaluate the success of a preseason program or a current phase of conditioning. Previous longitudinal studies have shown progressions of physique and the effect different phases of a year have upon measures of body composition. However, the long-term monitoring of individual players' physical performance, such as strength, power, and speed, has received less attention and requires further investigation. Because of a lack of knowledge in the area of long-term athletic development in rugby union, there is a need to understand the between-player differences and within-player changes over long periods of time.

Therefore, the primary purpose of this study was to analyze performance test data of New Zealand rugby union players from 2004 to 2007, to determine differences between playing positions, playing level, and year of fitness test; and changes within players as they moved between different competitions played during the year. It was hypothesized that (a) the differences between playing positions would be similar to those already reported in literature; (b) players of higher playing levels would perform better than players of lower levels; (c) players would show small annual improvements in physical performance; and (d) players would perform better during higher-level competitions.

Methods

Experimental Approach to the Problem

A large battery of fitness tests that are deemed important for the physical preparation of rugby union players are performed on all registered players in New Zealand at provincial level and above. Performance test data that have been determined through these fitness tests, performed under standardized testing protocols, are entered onto a national database. With this large amount of data available, the New Zealand Rugby Union was able to commission research into the progressions and differences between annual means, playing level, and competition phases. To deal with the large amount of repeated measures on players, the differences between and changes within players were determined through appropriate statistical modeling.

Data Source

Performance test data for 1,161 players were downloaded from the Performance Profiler Database (NZRU Version 7; Profiler Corporation, Dunedin, New Zealand). The Performance Profiler Database contains results from performance tests, conducted by various strength and conditioning coaches, on all regional representative and professional players in New Zealand. Data were only entered into the database if the test was performed using the stipulated New Zealand Rugby Union testing procedures (see below). Although these procedures were provided to standardize the testing, the interpretation of the protocols and test performance (nutrition, hydration, and time of day) may be different between individuals. Nonetheless, players were typically tested by the same individual strength and conditioning coach, thus minimizing the variation associated with multiple testers (20). No familiarization trials were performed as players were familiar with testing protocols and had tested on numerous occasions before the period of this study.

Data on body composition, strength, power, speed, and repeated sprint ability from the beginning of the Super Rugby preseason 2004 (1 December, 2003) through to the conclusion of the international end of year tour (World Cup) 2007 (25 November, 2007) was downloaded from the database. Each of the 4 years included in the analysis were divided into specific phases of the year, which included the preseason training periods and the competition phases of the respective competitions. The professional Super Rugby season running from the beginning of December the previous year through to May; the midyear international competition from May to August; the semiprofessional national provincial competition (in which Super Rugby players also participate) from July to October; and the international end of year competition from October to the end of November.

Informed consent for each player was obtained through the player registration form each player must sign at the beginning of each rugby season. The form stipulates that any data collected from the player may be used at the discretion of the New Zealand Rugby Union for research or data analysis purposes. The study was approved by the Auckland University of Technology Ethics Committee.

Procedure

Body Composition. Anthropometric measurements included body mass and sum of 8 skinfolds (bicep, triceps, subscapular, abdominal, supraspinale, iliac crest, front thigh, and medial calf). Body mass was measured on calibrated scales, and each skinfold site was located and measured as per the International Society for the Advancement of Kinanthropometry (ISAK) guidelines (25). Percentage body fat was calculated from estimated body density (36) using the equation derived from Siri (31). Fat-free mass was calculated from the player's body mass and calculated body fat (fat-free mass = body mass − (body mass × percentage body fat/100)) (32). Data were only included if all technical errors of measurement were below the upper limits recommended by Perini et al. (27).

Strength and Power. 1RM was calculated for a series of resistance training exercises from a 2–6 repetition maximum lift using the formula derived by Landers (22). The strength exercises included bench press, box squat, back squat, and

chin-ups, whereas the power clean was used to indicate full body power. Each exercise was assessed for correct technique by a trained strength coach and only repetitions performed unassisted with correct technique were recorded.

When performing the bench press, the feet were to remain in contact with the floor and the buttocks and lower back had to remain in contact with the bench throughout the lift. During the lift, the bar was to be lowered to the chest (with elbows at approximately 90° and not bouncing off the chest) and returned to the start position where elbows were to be fully extended but not locked. Each player used a self-selected hand position. The back squat required the player to descend in a controlled manner until the top of the thighs were parallel with the floor before returning to the standing position. The box squat was performed in a similar manner however the player was instructed to pause briefly in the seated position on a box where the thighs were parallel with the floor. Players used a self-selected foot position, and powerlifting belts were not used during the lifts. When performing the chin-ups, a reverse underhand grip (palms facing toward face) was used. Players were instructed to start from a stationary position with arms fully extended and complete a repetition with the chin moving over the bar (2,5). The power clean required the player to set up in a crotched position over the bar on the floor with fully extended arms. From this position, the player was instructed to thrust upward in a triple extension movement, pulling the barbell upward into the catch position on the front of the shoulders with elbows forward (4). Between repetitions, the player must have stayed connected with the bar. The coefficients of variation (CV) for similar strength testing protocols within professional rugby union players have been shown to be approximately 4.5% (2).

Speed. All sprints (both speed and repeated sprints) were performed on grass; however, a synthetic grass mat covering 1.5 m behind and 3.5 m in front of the first timing gate (securely pegged at each corner) was laid to assist with traction. All sprints were performed in footwear that was appropriate for the conditions and those used during rugby matches (moulded soles for firm and hard ground, football boots for softer ground). The players were instructed to sprint maximally for every repetition within the lane formed by the Swift (Swift Performance Equipment, NSW, Australia) or Smart Speed (Fusion Sport, Queensland, Australia) electronic timing gates, which was approximately 2-m wide. Players started each sprint with their foot on a line 50 cm from the light beam of the first timing gate, in a stationary upright position, with no rocking back or forth before starting.

Each player performed 2 repetitions over 20 m for forwards and half backs and 30 m for backs. For each repetition, the time to complete the total distance (20 or 30 m) and the time to cover the first 10 m of each sprint was recorded, with the fastest overall time recorded. Each of the 2 efforts was performed after at least 2-minute rest from the previous repetition. The CV for speed has been shown to be 0.9–3% (34).

Repeated Sprint Ability. Repeated sprint ability was tested using the Rugby-Specific Repeated-Speed (RS^2) test. The first component of the test is a measure of speed and is performed as described above. The speed component allows a comparison of effort to be made between the sprints performed during the repeated sprint component of the RS^2 test. Five minutes after completing the speed component, the repeated sprint component was performed. The repeated sprint component consists of 3 sets of 3 or 4 individual sprints performed maximally at set time intervals. Each set of sprints is separated by periods of standardized work where the players jog with a weighted bag (PowerBag; SPSS, Christchurch, New Zealand) over their shoulders and perform down and ups (get down off feet into a prone position on the ground–chest and chin was required to touch the ground–and then return to feet), also at set time intervals (Figure 1). Players repeated sprints were measured using electronic timing gates over the same distance as speed (30 m for backs and 20 m for forwards and half backs); however, only the time to complete the total distance was recorded.

Two groups of 3 forwards (6 total) or 4 backs (8 total) were able to perform the repeated sprint component at 1 time. The master timer started a stopwatch and sent individual players off at 10-second intervals. The master timer started the players by counting down the time left before the start of the next repetition of work from 5-seconds (i.e., 5; 4; 3; 2; 1; GO!). During the periods of standardized work, the master timer was required to countdown for all the players, as in some instances, all subjects were performing some form of work at the same time.

Forwards. The forwards (including the half backs) were required to sprint 4 times over 20 m, sprinting through the timing gates, decelerating to a cone a further 10 m away. They then jogged back toward the timing gates (total distance decelerating/jogging = 20 m), and upon reaching the gates walked back to the start line outside the running lane (total distance walking = 20 m). Each sprint repetition was performed on a 30-second turnaround. After completing 4 sprints (at master time 2 minutes), the player moved to the side of the running lane and performed the standardized work. The player was required to pick up the 30-kg PowerBag and place it on their shoulder or behind their neck. On the GO command, they had 10 seconds to carry it 20 m and drop the PowerBag at the end. On a 10-second turnaround, the player performed a down and up (get down off feet into a prone position on the ground–chest must touch the PowerBag–and then return to feet) before picking up the PowerBag and jogging with it for 20 m back to the start line. The players were to keep the bag on their shoulders before repeating the up and back shuttle. The standardized work

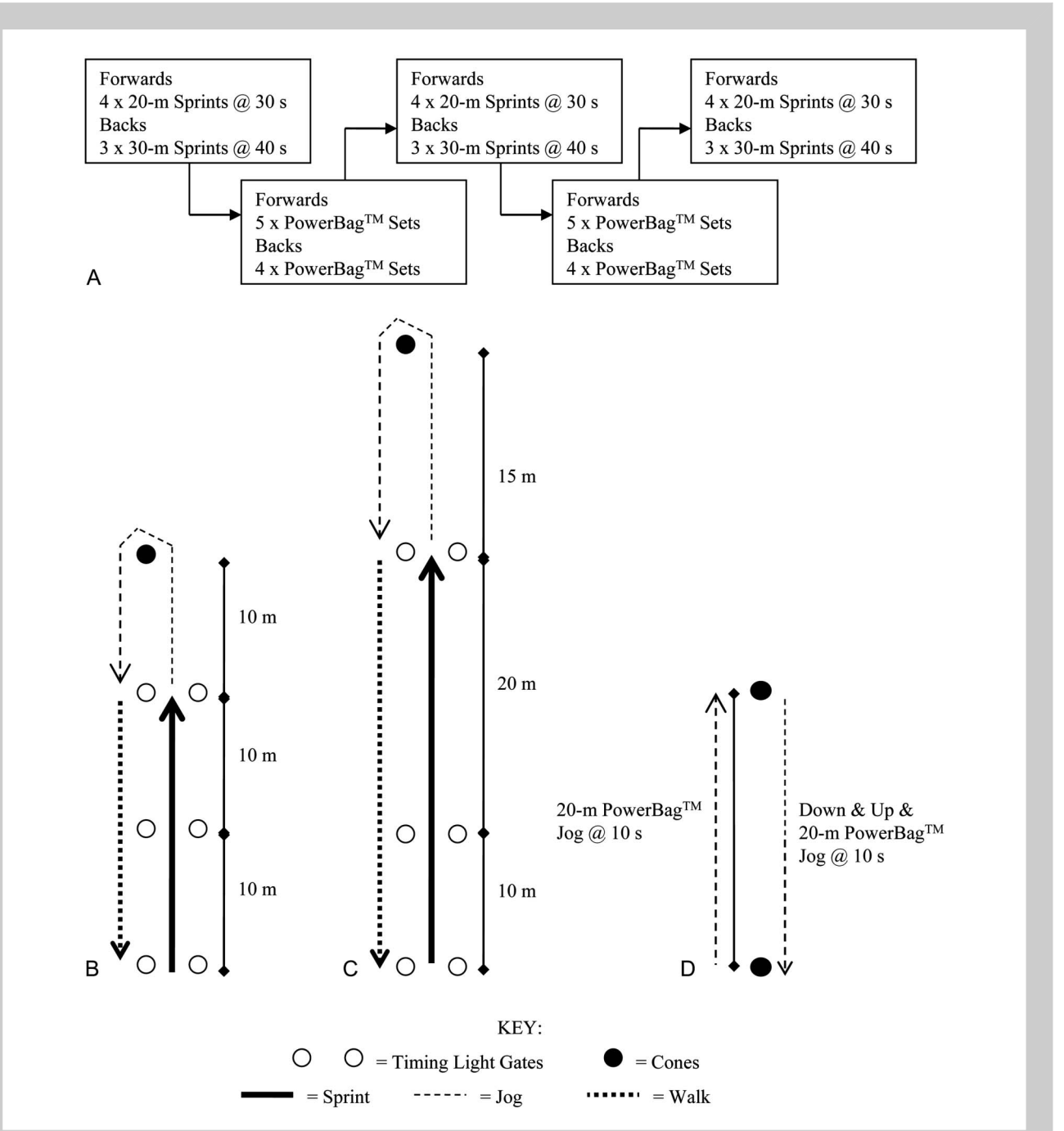

Figure 1. The repeated sprint component of the Rugby-Specific Repeated-Speed (RS^2) test (A). Three sets of repeated sprinting, jogging, and walking 20 m for the forwards (B) and 30 m for the backs (C) are performed at set time intervals and interspersed with PowerBag shuttles using a 30-kg weighted PowerBag, also performed at set time intervals (D).

sequence was performed a total of 5 times. After a 20-second rest (at master time 4 minutes), the player repeated the previous sprint and standardized work protocol. Upon completion of the second period of standardized work, the players completed the final set of 4 sprints. A total of 12 sprints was therefore performed over a period of 9 minutes 30 seconds.

Backs. The backs (not including the half backs) were required to sprint 3 times over 30 m, sprinting through the timing gates decelerating to a cone a further 15 m away. They then jogged back toward the timing gates (total distance decelerating/jogging = 30 m) and upon reaching the gates walked back to the start line outside the running

lane (total distance walking = 30 m). Each sprint repetition was performed on a 40-second turnaround. Upon completing 3 sprints (at master time 2 minutes), the player moved to the side of the running lane and performed the standardized work shuttles. The PowerBag sequence explained in the forwards protocol was performed 4 times. After a 30-second rest (at master time 4 minutes), the player repeated the previous sprint and standardized work protocol. After completing the second period of standardized work, the player completed the final set of 3 sprints. A total of 9 sprints were therefore performed over a period of 9 minutes 20 seconds.

Performance Variables for the RS² Test. Measures of performance derived from the RS² test were: the mean time per sprint, fatigue (calculated as a percent change in sprint time predicted from the linearized change derived from all sprints performed), and mean of 12 vs. 20 m for forwards and mean of 9 vs. 30 m for backs (the percent difference between the mean time per sprint and the corresponding sprint time performed during the first component of the RS² test). The CV's for the performance variables of the RS² have been shown to be 0.8–2.3% (33,34).

Statistical Analyses

Players were identified and grouped according to their playing position (props, hookers, locks, loose forwards, inside backs, centers, outside backs) and competitive level at time of test (in order of highest to lowest playing level: international, Super Rugby, provincial, and players not selected for provincial). The mixed modeling procedure (Proc Mixed) in the Statistical Analysis System (Version 9.2; SAS Institute, Cary, NC, USA) was used to determine the differences between positions, playing level, and year of fitness test. The differences between levels were adjusted to 2007, the last year of the data and year with the most data. The fixed effects were the highest playing level achieved in each year and the interaction of this variable with the year of test (as a linear numeric variable, to estimate a different progression within each level). The random effects were the identity of the player (to estimate consistent differences between players), the interaction of player identity and year (to estimate within-player variation between years), and the residual (representing variation within player for any tests repeated within a year). A similar model was used in the analysis of the changes within players between different competition periods during the same year. The fixed effects were the year of competition (as a nominal variable, to adjust for any consistent changes between years) and the level of competition at the time of the test (to estimate consistent changes as players move between competition periods within the same year). The random effects were the same as the previous model. Mechanistic inferences about magnitudes of effects were based on acceptable uncertainty in the effect estimates (21). All results were expressed as single values to represent the mean within-athlete changes and between-athlete differences over the 4 year period. Uncertainty was defined by confidence intervals, with a 99% level chosen to reduce the error rate for clear outcomes. Differences between and changes within players were standardized and assessed for magnitude using a modified Cohen scale: <0.2 = trivial, 0.2–0.59 = small, 0.6–1.19 = moderate, 1.2–1.99 = large, >2.0 = very large (21).

Results

Differences Between Positions

The mean performance and anthropometrical outcomes for each positional group are summarized in Table 1. Mean performance in speed, body composition, strength, and power showed the expected differences between positional groups. Outside backs had the fastest 10, 20, and 30 m sprint time, and their differences between other positions ranged from small (0.02 seconds with centers over 10 m) to very large (0.32 seconds with props over 20 m). Trends showed a linear decrease in speed time as the positional number increased (props jersey number 1, through to fullback [outside back] jersey number 15). Props were the heaviest and had the largest skinfold thickness, percent body fat, and fat-free mass. In a similar trend to speed, skinfold thickness and percent body fat linearly decreased as positional number increased. Differences between positions in strength and power were highly varied and dependent upon the exercise performed. Trivial to small differences in bench press (9 kg), box squat (0 kg), and back squat (9 kg) 1RM were found between the front row positions (props and hookers). However, when the front row positions were compared with other positions, differences were small to large. Differences between the inside backs (half backs) and the forwards in the forwards RS² test ranged from small (0.9% with loose forwards for mean of 12 vs. fastest) to very large (0.33 seconds with props for mean of 12 sprints). Small differences in the backs RS² test occurred between the inside backs and outside backs (all 3 RS² test performance variables), centers and inside backs (backs fatigue), and centers and outside backs (mean of 9 sprints).

Differences Between Playing Levels

The percent differences between playing levels for forwards and backs are shown in Table 2. The differences between Super Rugby and provincial players were dependent upon the positional group. The forwards had small (7.7%; 99% confidence limits ± 8.2% for back squat 1RM) to moderate (13.3%; ±4.8% for bench press 1RM) differences in all strength and power measures, whereas the backs had small (1.9 ± 1.5% for 30-m sprint) to moderate (4.5%; ±1.7% for 20-m sprint) differences in all speed measures. Few performance variables showed clear differences between Super Rugby and international players. The only difference of substantial magnitude within both the forwards and backs between international and Super Rugby players was the small difference in 20-m sprint (1.9%; ±2.1% for forwards and 2.2%; ±2.2% for backs).

Table 1. Mean ± coefficient of variation (%) of physical performance and anthropometric tests in rugby union players, calculated with equal contribution from level of player (amateur, semiprofessional, and professional) and year of test (2004–2007), separated into positional groups.

	Props, $n = 143$	Hookers, $n = 85$	Locks, $n = 121$	Loose forwards, $n = 207$	Insides, $n = 212$	Centers, $n = 58$	Outside backs, $n = 172$
10-m sprint (s)	1.85 ± 4.7	1.81 ± 4.1	1.79 ± 4.7	1.76 ± 4.5	1.72 ± 4.0	1.70 ± 4.0	1.68 ± 4.4
20-m sprint (s)	3.21 ± 4.4	3.14 ± 3.7	3.13 ± 4.2	3.06 ± 4.4	2.96 ± 3.5	2.95 ± 4.6	2.89 ± 3.3
30-m sprint (s)					4.14 ± 4.1	4.12 ± 4.2	4.11 ± 3.9
Body mass (kg)	113.5 ± 8.1	104.9 ± 6.4	109.4 ± 7.6	101.6 ± 7.9	88.8 ± 9.2	94.1 ± 6.3	89.2 ± 9.0
Skinfold thickness† (mm)	114 ± 26	102 ± 26	88 ± 29	84 ± 30	74 ± 35	74 ± 26	65 ± 25
Percent body fat (%)	16.1 ± 26	14.5 ± 25	12.7 ± 29	12.1 ± 28	10.7 ± 32	10.6 ± 24	9.4 ± 23
Fat-free mass (kg)	94.4 ± 7.9	88.5 ± 6.2	95.0 ± 6.4	88.9 ± 7.0	78.8 ± 8.2	83.9 ± 6.3	80.8 ± 8.6
Bench press 1RM (kg)	133 ± 18	124 ± 17	121 ± 17	119 ± 16	111 ± 16	113 ± 15	109 ± 16
Box squat 1RM (kg)	185 ± 19	185 ± 25	157 ± 21	169 ± 26	155 ± 20	163 ± 23	157 ± 20
Back squat 1RM (kg)	184 ± 19	175 ± 20	141 ± 21	161 ± 21	141 ± 20	151 ± 17	145 ± 24
Chin-ups 1RM (kg)	140 ± 10	137 ± 9	139 ± 11	132 ± 11	123 ± 11	127 ± 9	123 ± 11
Power-clean 1RM (kg)	102 ± 14	101 ± 14	103 ± 17	98 ± 18	91 ± 16	93 ± 15	91 ± 20
Mean of 12 sprints‡ (s)	3.44 ± 5.5	3.35 ± 4.0	3.31 ± 4.5	3.23 ± 4.6	3.11 ± 3.7*		
Mean of 9 sprints‡ (s)					4.30 ± 4.0	4.33 ± 4.9	4.25 ± 4.0
Forwards fatigue§‖ (%)	3.9 ± 5.1	4.6 ± 3.9	3.0 ± 4.1	3.8 ± 4.7	2.3 ± 3.6*		
Backs fatigue§‖ (%)					3.1 ± 3.7	4.9 ± 5.1	4.1 ± 4.6
Mean of 12 vs. 20 m‖¶ (%)	7.4 ± 4.1	7.0 ± 3.1	6.4 ± 2.9	5.9 ± 3.3	4.8 ± 3.1*		
Mean of 9 vs. 30 m‖¶ (%)					4.8 ± 2.8	5.9 ± 3.8	5.9 ± 3.4

*Halfbacks performed forwards protocol.
†Sum of 8 skinfolds.
‡Mean time for sprints performed in Rugby-Specific Repeated-Speed test.
§Fatigue for the Rugby-Specific Repeated-Speed test.
‖Data expressed as mean ± *SD*.
¶The percent difference in time between the mean time and sprint time in the Rugby-Specific Repeated-Speed test.

Table 2. Mean differences (%); ±99% confidence limits in physical performance and anthropometry between rugby union players of different playing levels in the 2007 year within forwards and backs positional groups.*

	Forwards				Backs			
	Provincial, not selected	Super Rugby, provincial	International, Super Rugby	International, provincial	Provincial, not selected	Super Rugby, provincial	International, Super Rugby	International, provincial
10-m sprint	0.8; ±1.2†	−0.7; ±1.4†	−0.6; ±2.3	−2.1; ±2.3‡	−2.2; ±1.2‡	−3.7; ±1.4§	−1.9; ±2.0‡	−3.4; ±2.0§
20-m sprint	1.1; ±1.2‡	0.1; ±1.4†	−1.9; ±2.1‡	−2.1; ±2.2‡	−2.4; ±1.7§	−4.5; ±1.7§	−2.2; ±2.2‡	−4.3; ±2.2§
30-m sprint					−2.1; ±1.4‡	−1.9; ±1.5‡	−2.8; ±2.1§	−2.6; ±2.2§
Body mass	2.3; ±1.6‡	3.6; ±1.9‡	0.2; ±2.0	1.4; ±2.4†	2.3; ±1.6‡	2.9; ±1.9‡	−0.5; ±2.0†	0.1; ±2.4
Skinfold thickness	−2.7; ±5.9†	−7.7; ±6.4	−0.9; ±8.2	−5.9; ±8.7‡	−9.7; ±5.5‡	−11.3; ±6.2‡	−6.5; ±7.7‡	−8.2; ±8.7‡
Percent body fat	−3.6; ±5.6†	−8.8; ±6.1‡	−1.2; ±7.8	−6.6; ±8.3‡	−9.6; ±5.3‡	−12.6; ±5.8‡	−6.1; ±7.4‡	−9.1; ±8.1‡
Fat-free mass	3.1; ±1.4‡	5.2; ±1.7§	0.0; ±1.8†	2.1; ±2.1‡	3.1; ±1.5‡	4.1; ±1.7	0.0; ±1.7†	1.0; ±2.1†
Bench press 1RM	8.5; ±3.9‡	13.3; ±4.8§	0.4; ±6.6	4.9; ±7.4‡	11.3; ±4.4§	13.0; ±5.3§	−0.4; ±7.2	1.2; ±7.7
Box squat 1RM	6.2; ±9.6‡	10.5; ±10.6‡	7.5; ±18.0	11.8; ±19.4	8.9; ±9.9‡	1.0; ±9.2	−1.8; ±15.4	−8.9; ±14.6
Back squat 1RM	11.1; ±7.4‡	7.7; ±8.2‡	1.4; ±12.5	−1.7; ±12.1	14.0; ±7.9§	6.7; ±8.9‡	−0.2; ±16.1	−6.6; ±14.5
Chin-ups 1RM	8.2; ±3.1§	10.3; ±3.5§	6.3; ±7.7§	8.3; ±7.9§	4.9; ±3.4‡	5.6; ±4.0‡	0.7; ±6.8	1.4; ±7.0
Power-clean 1RM	7.2; ±5.9‡	12.0; ±6.5§	7.7; ±9.6‡	12.5; ±10.3§	9.9; ±7.7‡	15.2; ±8.6§	1.5; ±11.2	6.4; ±11.9
Mean of 12 sprints	0.2; ±1.8	−0.7; ±2.0	−1.6; ±2.8	−2.6; ±2.8‡	−3.5; ±4.1§	−7.0; ±4.3‖	−3.1; ±6.0	−6.7; ±5.9‖
Mean of 9 sprints					−1.7; ±1.1‡	−1.8; ±1.9‡	−3.2; ±2.5§	−3.3; ±2.6§
Forwards fatigue	−1.8; ±1.5‡	−2.0; ±1.6‡	1.1; ±2.3	0.9; ±2.3	−3.2; ±3.1§	−4.2; ±3.3§	−0.8; ±4.8	−1.8; ±4.7
Backs fatigue					−0.1; ±1.9	−0.4; ±2.0	2.4; ±3.1‡	2.0; ±3.0
Mean of 12 vs. 20 m	−0.4; ±1.2	−0.7; ±1.3†	0.0; ±1.9	−0.2; ±1.9	−3.0; ±2.6§	−4.4; ±2.8‖	0.6; ±4.1	−0.8; ±4.0
Mean of 9 vs. 30 m					0.7; ±1.4	0.2; ±1.6	0.4; ±2.2	−0.1; ±2.2

*A negative value indicates a greater value for the lower playing level (stated second).
†Trivial difference.
‡Small difference.
§Moderate difference.
‖Large difference; all other differences were unclear.

Table 3. Average annual changes (%); ±99% confidence limits in physical performance or anthropometry in rugby union players between 2004 and 2007, within different playing levels for forwards and backs.

	Forwards				Backs			
	Not selected	Provincial	Super Rugby	International	Not selected	Provincial	Super Rugby	International
10-m sprint*	−0.1; ±1.0†	1.4; ±1.1‡	−0.6; ±1.1†	−0.9; ±1.9	1.0; ±1.1‡	1.4; ±1.1‡	0.4; ±1.0†	−1.4; ±1.6‡
20-m sprint*	−0.6; ±1.1†	1.5; ±1.1‡	0.1; ±1.0†	−0.9; ±1.8†	1.5; ±1.9‡	1.3; ±2.0‡	0.4; ±1.5	−1.0; ±1.8
30-m sprint*					1.1; ±1.5‡	0.8; ±1.1‡	1.2; ±1.0‡	−1.9; ±1.6‡
Body mass	1.1; ±0.8†	1.0; ±0.7†	0.7; ±0.6†	0.5; ±0.8†	0.2; ±0.7†	0.9; ±0.8†	0.9; ±0.6†	0.4; ±0.7†
Skinfold thickness	2.2; ±3.0†	3.2; ±3.1†	0.4; ±2.2†	−0.2; ±3.3†	0.8; ±3.0†	1.5; ±3.3†	1.2; ±2.5†	−1.2; ±2.9†
Percent body fat	2.5; ±2.9†	3.5; ±3.0†	1.0; ±2.1†	0.1; ±3.1†	1.3; ±2.9†	2.0; ±3.1†	1.2; ±2.4†	−0.8; ±2.8†
Fat-free mass	0.9; ±0.7†	0.6; ±0.7†	0.6; ±0.5†	0.4; ±0.7†	0.4; ±0.6†	0.8; ±0.7†	0.7; ±0.5†	0.4; ±0.6†
Bench press 1RM	4.6; ±2.8‡	5.0; ±2.3‡	4.6; ±2.4‡	3.5; ±5.0‡	4.7; ±2.9‡	8.4; ±3.2‡	5.7; ±3.1‡	5.3; ±5.3‡
Box squat 1RM	2.8; ±10.5	1.4; ±7.1	12.5; ±5.3‡	15.3; ±20.1§	0.4; ±11.0	6.9; ±8.4‡	8.8; ±7.4‡	8.4; ±18.4
Back squat 1RM	1.7; ±6.1	5.3; ±5.0‡	5.2; ±6.3‡	3.4; ±8.8	0.1; ±6.3	5.0; ±7.0‡	10.3; ±7.9‡	9.3; ±13.2‡
Chin-ups 1RM	2.1; ±2.2‡	2.4; ±2.1‡	0.4; ±2.3†	5.5; ±6.6‡	3.7; ±2.6‡	3.9; ±2.9‡	2.9; ±2.7‡	4.0; ±5.7‡
Power-clean 1RM	3.5; ±5.1‡	−1.5; ±4.5†	2.5; ±4.5	3.6; ±9.1	−3.7; ±6.9	2.1; ±5.9	1.8; ±4.7†	1.1; ±8.5
Mean of 12 sprint	−1.9; ±1.7‡	0.5; ±1.4†	−0.2; ±1.3†	−0.6; ±2.5	1.7; ±4.1	1.0; ±4.0	−0.4; ±4.2	−0.2; ±5.8
Mean of 9 sprints					0.4; ±1.9	0.4; ±1.4	1.1; ±1.2‡	−1.5; ±2.2‡
Forwards fatigue‖	−1.3; ±1.6‡	−1.3; ±1.3‡	0.1; ±1.1	0.1; ±2.1	2.0; ±3.3	0.0; ±3.2	−1.6; ±3.5	−0.2; ±4.9
Backs fatigue‖					−1.5; ±2.2‡	−1.5; ±1.7‡	0.5; ±1.7	2.8; ±3.2§
Mean of 12 vs. 20 m¶	−1.5; ±1.2‡	−0.7; ±1.0†	0.3; ±0.9†	0.4; ±1.7	1.3; ±2.7	−0.8; ±2.6	−1.3; ±2.9	1.2; ±4.1
Mean of 9 vs. 30 m¶					−1.9; ±1.6‡	−1.0; ±1.2	−0.4; ±1.1	1.0; ±2.1

*Negative value indicates a decrease in speed time (got faster).
†Trivial change.
‡Small change.
§Moderate change; all other changes were unclear.
‖Negative value indicates a reduction in RS^2 fatigue (greater repeated sprint ability).
¶Negative value indicates a mean time closer to sprint time (greater repeated sprint ability).

Table 4. Mean within-athlete changes (%); ±99% confidence limits in physical performance and anthropometry in rugby union players as they move from one competition period to another competition period within the same year.*

	Super Rugby to international†	Super Rugby to provincial	Provincial to international‡
10-m sprint	−1.8; ±0.9§	−0.7; ±0.5‖	0.3; ±0.9
20-m sprint	−1.4; ±0.8§	0.0; ±0.5‖	0.0; ±1.2
30-m sprint	−1.5; ±1.7§	−0.4; ±0.8‖	−1.1; ±2.2
Body mass	0.0; ±0.3‖	0.1; ±0.2‖	−0.2; ±0.4‖
Skinfold thickness	−1.0; ±2.3‖	−1.0; ±1.2‖	−1.8; ±3.2‖
Percent body fat	−1.3; ±2.1‖	−0.8; ±1.1‖	−2.1; ±2.9‖
Fat-free mass	0.1; ±0.4‖	0.3; ±0.2‖	−0.1; ±0.5‖
Bench press 1RM	1.0; ±4.1	0.5; ±1.1‖	
Box squat 1RM	8.3; ±14.1	8.0; ±3.0§	
Back squat 1RM	−2.7; ±10.0	5.9; ±3.9§	
Chin-ups 1RM	3.3; ±4.1§	1.3; ±1.2‖	
Power-clean 1RM	7.3; ±7.5§	2.8; ±2.9‖	
Mean of 12 sprints	−0.6; ±1.4	0.0; ±0.6‖	
Mean of 9 sprints	−1.6; ±1.7§	−0.1; ±0.9	
Forwards fatigue	1.8; ±1.8§	0.4; ±0.8‖	
Backs fatigue	2.4; ±2.0¶	0.8; ±1.0‖	
Mean of 12 vs. 20 m	1.2; ±1.2§	0.5; ±0.5‖	
Mean of 9 vs. 30 m	0.6; ±1.5	0.6; ±0.8‖	

*A negative value indicates a decrease in the variable from the preceding competition.
†Midyear competition.
‡End of year competition.
§Small change.
‖Trivial change.
¶Moderate change; all other changes were unclear.

Differences Between Years

The mean annual changes in performance within each level for forwards and backs is shown in Table 3. All anthropometrical measures showed trivial changes across all levels in both forwards and backs. All levels and positions showed small increases in bench press 1RM, and all except Super Rugby forwards showed small increases in chin-ups 1RM. Similarly, all levels, except the players not selected, showed small-to-moderate increases in lower body strength (either back squat 1RM, box squat 1RM or both). The lower-level players (not selected and provincial) appeared to improve more in the RS^2 test (both forwards and backs) compared with the higher-level players. Specifically, small decreases were observed in both forwards and backs fatigue (range, 1.3–1.5%) and small decreases were observed in mean of 12 vs. 20 m and mean of 9 vs. 30 m (range, 0.7–1.9%), indicating a better maintenance of maximal sprint performance.

Changes Within Players

Mean changes within player's performance as they moved from one competition period to another during the year is displayed in Table 4. Small increases occurred in box squat (8.0%; ±3.0%) and back squat (5.9%; ±3.9%) 1RM as players moved from Super Rugby to the provincial competition. Small decreases in all the speed times (range, 1.4–1.8%) and small increases in chin-ups (3.3%; ±2.6%) and power-clean (7.3%; ±4.8%) 1RM occurred as players moved from Super Rugby to the international midyear competition.

Discussion

Previous studies of the physical characteristics of players, not only in rugby union but also rugby league, have typically had small sample sizes that are tested on 1 or 2 occasions (9,11,14,17,19,23,24,28,29). This study is the first to use a sample size of such a large magnitude (over 1,100) with numerous repeated measurements in a wide variety of physical characteristics over a long period of time. The statistical power that the large number of observations has provided, enabled the use of narrow confidence intervals (99%), increasing the certainty of the clear outcomes reported.

Forwards were generally heavier, had greater skinfold thickness, percentage body fat, and fat-free mass than backs, with props the heaviest and the strongest. The outside backs were the fastest over all measured sprint distances, and the half backs and first five eights showed the lowest fatigue in both the forwards and backs RS^2 tests, respectively. The findings are consistent with those studies that have previously investigated the anthropometrical characteristics in rugby players (6–9,11,19,23,24,28–30). Props are generally the largest of the positions to contest the ruck, maul, and scrum situations to win or maintain possession of the ball. The inside backs are generally the smallest to be mobile around the field and agile around the scrum, ruck, and maul (12,19,28). Interestingly, the players in this study were more than 10-kg heavier than Senior A players (29) and up to 15-kg heavier than players in the early studies on the United States national team (24). The mass of players are more comparable to recent studies published on professional Super 12 players (2,11). The large difference highlights the rate at which the physique of rugby players is increasing, which may be a result of greater training loads and enhanced nutritional and recovery strategies that has accompanied professionalism.

Speed characteristics of the players in this study are similar to those previously reported in rugby union. Indeed,

backs have been shown to be faster over distances greater than 30 m than forwards, with outside backs the fastest (8,28,29). Differences in strength assessments on rugby players, however, make direct comparisons with other studies difficult. Nonetheless, when compared with a small sample of Super 14 players and professional rugby league players, the players in this study have lower power-clean 1RM; props are the only comparable position in bench press 1RM; and the hookers, props and loose forwards have greater back squat and box squat 1RM (1,3,4).

Few studies have specifically investigated the repeated sprint ability of rugby players. Furthermore, the novel protocol used in this study makes it difficult to compare with studies of other team sports. Because of the importance of the anaerobic energy supply for the repeated sprints performed during matches, further research is required specifically using tests similar in nature to the RS^2 test employed in this study (12). The RS^2 test replicates the distances and work to rest ratios of matches, and although is more time consuming to implement than a multistage shuttle test, can be used to assesses specific qualities of rugby union performance (12).

It seems that as playing level increases, players are faster, heavier, have greater fat-free mass, lower skinfold thickness and percent body fat and have greater strength and power. These results reinforce findings from previous studies illustrating level-specific fitness and physique characteristics that can distinguish between semiprofessional and professional players in rugby and rugby league (3,29). The differences between playing levels could be because of a greater training history and an increased requirement of strength and size within the professional game (3,12).

The increased physical capacity as playing level increases only seems to occur up to a certain level. A large number of trivial differences occurred between Super Rugby and international players in mass and strength in both the forwards and backs. The lack of consistent differences indicates that selection into the higher international level squad may not be determined by physical attributes as much as lower levels. Alternatively, international players may be selected because of greater skill and experience compared with Super Rugby players (15). The international players also compete within the Super Rugby competition, and the time between the conclusion of the Super Rugby competition and the beginning of the international midyear competition is negligible. Therefore, a combination of inadequate preparation time and a greater number of high-intensity matches may minimize the international players' ability to train to make increased physical gains over other Super Rugby players.

There were trivial increases in the average annual change of all anthropometrical variables over the period in which data were obtained. Similarly, Duthie et al. (11) reported trivial changes in mass over three years and small increases in sum of skinfolds in the third year of being involved in a Super 12 squad. The data from this study indicate minimal year to year changes in body composition, but does not discount substantial longitudinal changes from 2004 to 2007; following previous trends of players becoming heavier with greater fat free mass (26,30).

There were small to moderate annual increases in both upper and lower body strength. Interestingly, the Super Rugby and international players (all professional players) were able to increase strength up to 15% per year, indicating changes can still be made at higher playing levels. The moderate increases may be because of the improving professionalism of the players. Increased emphasis on physical enhancement strategies such as specific training techniques, nutrition, and recovery may have allowed the attainment of greater resistance training volumes and decreased injury rates, allowing players to train more regularly (13,16).

The greater improvement in the RS^2 test by the lower-level players may be because of their lower physical capacity as a result of a younger training age (16). Indeed, there were small to large differences between Super Rugby and provincial players and between international and provincial players in all 3 RS^2 test variables. The law of diminishing returns suggests that the rate of improvement in a player's fitness is inversely proportional to their initial level of fitness (10). Therefore, higher-level players in this study with greater repeated sprint ability have limited scope for improvements in performance compared with provincial players and those not selected.

Rugby in New Zealand is unique in that a player may play up to 4 different competitions during 4 distinct periods within a year. Because of this unique situation, very little research has investigated the players change in physical performance between respective competitions. This study is the first that has specifically investigated the changes in physical performance as players moved from different competitions.

As the players moved from the Super Rugby to provincial competition, they had small increases in lower-body strength. Furthermore, as players moved from Super Rugby to the international midyear competition, they had small increases in chin-ups and power-clean 1RM and small decreases in sprint time over all distances. The results show that the Super Rugby competition does not allow a player to achieve optimal performance in aspects of strength, power, and speed compared with other competition periods during the year. The Super Rugby competition has potentially higher match intensity than the provincial competition and is performed over 3 continents (New Zealand, Australia, and South Africa), requiring a large amount of travel between the weekly matches. Furthermore, conditioning strategies employed by team management will be specific to the requirements of their own team and their schedule exclusively within the Super Rugby competition. A combination of these factors may contribute to the decrease in training load that has been

shown from preseason to in-season in Super Rugby players (2). The reduction in training load may therefore not provide adequate stimulus for the achievement of high levels of physical performance during the competition compared with other competition periods. However, increasing training load in-season to achieve higher levels of physical performance may not be appropriate. Increased training loads have been related to higher injury rates in rugby league players (18), whereas it is unknown whether increases in training load, in conjunction with high game loads, will allow the players to recover effectively for optimal performance during matches (2).

Practical Applications

This study is the first to use longitudinal data to describe the between-player differences and within-player changes in physical performance in rugby union players. The data have provided normative profiles for different positions, multiple playing levels, and the expected long-term improvements in physical performance. Data such as these will inform coaches, so that they have better understanding of what should be expected and what could be achieved with a rugby player over a long period of time. The novel aspect of the study was the physical changes within players from one competition to another. The information should help coaches develop strategies, such as more specific periodization and recovery, to improve the decrements in performance during specific times of the year.

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