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Human Kinetics
ORIGINAL INVESTIGATION

Mechanical Properties of Sprinting in Elite Rugby Union and Rugby League

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Purpose: To compare mechanical properties of overground sprint running in elite rugby union and rugby league athletes. ***Methods:*** Thirty elite rugby code (15 rugby union and 15 rugby league) athletes participated in this cross-sectional analysis. Radar was used to measure maximal overground sprint performance over 20 or 30 m (forwards and backs, respectively). In addition to time at 2, 5, 10, 20, and 30 m, velocity-time signals were analyzed to derive external horizontal force–velocity relationships with a recently validated method. From this relationship, the maximal theoretical velocity, external relative and absolute horizontal force, horizontal power, and optimal horizontal force for peak power production were determined. ***Results:*** While differences in maximal velocity were unclear between codes, rugby union backs produced moderately faster split times, with the most substantial differences occurring at 2 and 5 m (ES 0.95 and 0.86, respectively). In addition, rugby union backs produced moderately larger relative horizontal force, optimal force, and peak power capabilities than rugby league backs (ES 0.73–0.77). Rugby union forwards had a higher absolute force (ES 0.77) despite having ~12% more body weight than rugby league forwards. ***Conclusions:*** In this elite sample, rugby union athletes typically displayed greater short-distance sprint performance, which may be linked to an ability to generate high levels of horizontal force and power. The acceleration characteristics presented in this study could be a result of the individual movement and positional demands of each code.

Keywords: acceleration, sprint kinetics, radar gun, power, body orientation

Rugby union and rugby league are collision sports that require intermittent bouts of maximal sprint running.[1,2] Although the majority of sprinting efforts occur over relatively short distances (ie, <30 m), athletes will repeatedly achieve maximum acceleration and velocity during competition.[3,4] Thus a successful rugby code athlete at an international (elite) level must be proficient over the different phases of sprint running, including initial acceleration and maximum velocity.

There are distinctions in physiological profiles between rugby union and rugby league owing to the differing training and competition demands of each sport. Rugby league features fewer on-field players than rugby union (13 vs 15), resulting in greater distance between positions, therefore allowing athletes to obtain higher sprinting velocities. Moreover, rules regarding engagement around a ruck or tackle result in a disparity in space between codes. Namely, rugby union rules allow athletes to contest for ball after tackle, which results in lower-orientation, force-dominant movements. Competition play is punctuated with short maximal accelerations with athletes driving over the ball for possession and resisting attacks from opposing players. Rugby league athletes, however, must back-pedal 10 m toward their half, initiating more open space to sprint, which gives credence to higher hits to keep the ball from going to ground. In addition to between-codes differences, there are noted differences in physiological demands between the forward and back positions of both rugby union[1] and rugby league.[4,5] For example, positional differences have been identified in anthropometric characteristics, short-distance sprint performance, and horizontal force output between forwards and backs in professional rugby league athletes.[5]

During sprint acceleration, the orientation of ground-reaction force (GRF) has been shown to be a stronger indicator of performance than overall magnitude.[6,7] Thus, athletes who train with differing body orientations, and therefore force-application techniques,[6] may display different acceleration capabilities. With noted differences in physiology and strength profiles between rugby codes,[8] it could be hypothesized that each would display different capacities for force orientation at lower or higher velocities. This could occur from code-specific training, on-field competition demands, or a combination of the 2.

Linear force–velocity (*F*–*v*) and parabolic power–velocity (*P*–*v*) relationships have been used to profile the macroscopic external mechanical capabilities of the neuromuscular system during a host of multijoint movements.[9–14] Researchers have reported these capabilities during overground sprinting.[15] Essentially, the *F*–*v* relationship can indicate an athlete's ability to produce net horizontal GRF with increasing velocity and is summarized by the following variables: theoretical maximum force (F_0), theoretical maximum velocity (v_0), and maximum power (P_{max}) produced during the given movement.[12,16] Graphically, F_0 and v_0 represent the extreme ends of the linear *F*–*v* relationship, and P_{max} represents the apex of the parabolic *P*–*v* curve (see Figure 1).[14] As the relationship between these variables encompasses the entire capability of the neuromuscular system, it is inclusive of mechanical properties of individual muscles, morphological features, and neural mechanisms underpinning motor-unit drive. Moreover, these variables integrate

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an athlete's ability to orient the total (ie, resultant) force developed in a forward horizontal direction. Hence, F_0 and v_0 also depend on athlete ability to orient force effectively onto the ground at low and high running velocity, respectively. The addition of theoretical and maximal outputs allows for a more comprehensive analysis of the properties underlying sprint performance.[14]

The purpose of this study was to determine and compare mechanical properties of overground sprinting between elite rugby union and rugby league athletes using a recently validated field measurement technique.[15,17] Given that previous authors have reported differences in sprinting kinematics and kinetics between forwards and backs in both codes,[5,18] we separated the athletes by position. Although the current study design does not allow for investigation into the cause and effect of long-term training, it provides a useful model for comparisons between similar athletes who train and compete with different body orientations. Such information could potentially be used to monitor athletic performance and inform individualized training strategies.[15,19,20]

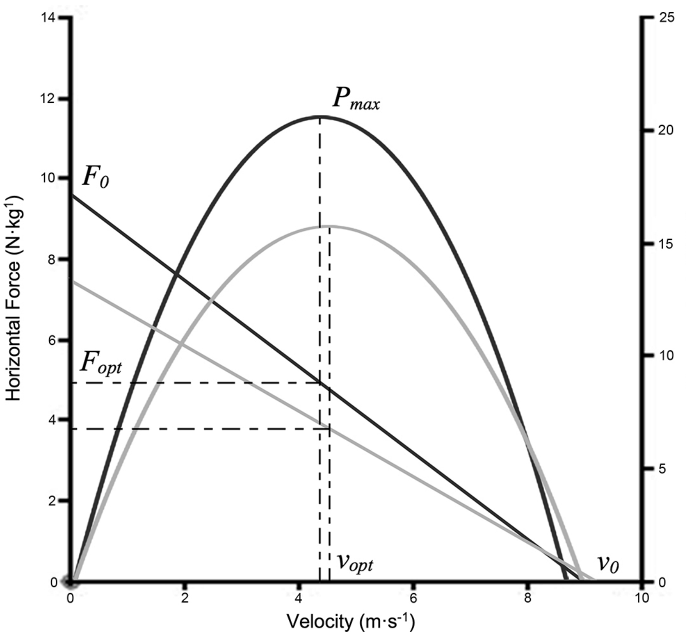

Figure 1 — A graphical representation of the force-velocity-power profiles (and associated optimal force and velocity levels for power production) for 2 athletes from each code (light gray [rugby league player] vs dark gray [rugby union player]) over a 30-m maximal overground sprint. Abbreviations: P_{max}, maximum power; F_0, theoretical maximum force; F_{opt}, optimum force.

Methods

Subjects

Thirty elite rugby code (15 rugby union and 15 rugby league) athletes volunteered as participants in this study (see Table 1). Athletes were placed in a participant pool respective of their code and position, classifying them as rugby union or rugby league and forwards or backs. Fifteen rugby union athletes were grouped into 8 forwards and 7 backs, based on their regular playing position. All athletes represented New Zealand and were involved in the subsequent 2013 Investec Rugby Championship campaign. Fifteen rugby league athletes were grouped into 6 forwards and 9 backs, similarly based on their regular playing position. This elite group of athletes was drawn from a larger pool of data collected on a professional rugby league team, based on their participation at international level. Athletes represented New Zealand (n = 7), Tonga (n = 5), Australia (n = 1), Cook Islands (n = 1), and Samoa (n = 1). All participating athletes were free of any lower-extremity musculoskeletal or neuromuscular injuries that would have affected their ability to perform the required sprinting task at a maximal effort. Ethics approval for this study was granted by the Auckland University of Technology Ethics Committee (12/332).

Design

This cross-sectional study sought to investigate code and positional differences in time-to-distance splits and power-force-velocity characteristics through a recently validated method using spatiotemporal

Table 1 Athlete Characteristics

	Rugby Union N = 15; 8 forwards, 7 backs	Rugby League N = 15; 6 forwards, 9 backs	ES (CI)	Inference
Age (y)				
forwards	28 ± 5	25 ± 3	0.59 (–0.30;1.48)	Unclear
backs	24 ± 3	24 ± 2	0.29 (–1.17;0.58)	Unclear
Height (m)				
forwards	1.90 ± 0.1	1.87 ± 0.1	0.38 (–0.51;1.27)	Unclear
backs	1.82 ± 0.1	1.80 ± 0.1	0.09 (–0.76;0.95)	Unclear
Mass (kg)				
forwards	114.55 ± 6.3	107.13 ± 7.3	1.01 (–0.09;1.94)	Moderate**
backs	92.64 ± 4.9	94.57 ± 11.5	0.16 (–0.97;0.66)	Unclear

Note: Values are mean ± SD or effect size (ES) ± 90% confidence interval (CI).
**Likely, 75–94%.

data to estimate horizontal GRF during maximal overground sprinting.[15,17] The athletes involved in this study were recruited during their competitive season of play, and the testing instance was performed as the first in a battery of profiling tests during a week of active rest from competitive play. All testing occurred in the first quarter of the competitive season where it was expected that performance would be beginning to peak with minimized effects of fatigue. Testing occurred on a single day (for each team) after a day of rest (~24 h) and previous to any other training or testing that was occurring that day. The primary author of this research article performed all testing and subsequent analysis.

Methodology

All testing procedures were completed on the same modern artificial-turf surface, specialized for outdoor field-sport events. All athletes wore sprigged training shoes and team training attire. Each team performed a 15-minute on-field dynamic warm-up protocol specific to their respective sport, as this would most closely reflect the warm-up used before training, practice, and competitive match scenarios. All athletes were allowed a 3-minute active-recovery period before testing commenced, during which time a verbal explanation of testing procedures occurred. As all athletes in this study were highly accustomed to the testing being performed, only a single familiarization trial was performed, consisting of a 30-m sprint at ~80% of maximum effort through the marked course.

For the test trial, the athlete would step up to the starting line in a standing split-stance position with his preferred lead foot forward behind the line. A Stalker Acceleration Testing System (ATS) II radar device (Model: Stalker ATS II, Applied Concepts, Dallas, TX, USA) was secured via a bracket adapter to a heavy-duty tripod positioned 3 m behind the starting line at a height of 1 m above the ground (corresponding approximately to subject's center of mass). The radar device was set to measure forward sprinting velocity at a rate of 46.9 samples/s and was operated remotely via laptop connection so as to negate the possibility of variability introduced through direct manual operation. The validity of this device has been clearly proven from comparison against photoelectric cells in previous studies examining sprint-running performance.[21–23]

The athletes performed 20- or 30-m (for forwards and backs, respectively) sprints at maximum velocity through a running lane marked with parallel cones in 5-m increments. All athletes presented the same maximal involvement throughout the sprint to ensure that pacing was the same regardless of distance covered. Athletes were encouraged to sprint "through" each distance marker to ensure a full maximal collection devoid of deceleration.

All data were collected using STATS software (Model: Stalker ATS II Version 5.0.2.1, Applied Concepts, Dallas, TX, USA) provided by the radar device's manufacturer. A custom-made LabVIEW program (Build version: 11.0, National Instruments Corp, Austin, TX, USA) was developed to analyze horizontal external force, velocity, and power from the raw data set. The methods of obtaining these variables have recently been validated using speed data collected in a similar method during the acceleration phase of a maximal sprint.[17]

Each individual sprint velocity–time curve ($v[t]$) was fitted by a monoexponential function using least-squares regression:

$$v(t) = v_{max} \times (1 - e^{-t/\tau})$$

with τ the acceleration time constant. The horizontal acceleration of the center of mass can be expressed as a function of time, after derivation of velocity over time:

$$a(t) = (v_{max}/\tau) \times e^{-t/\tau}$$

Net horizontal force (F_h) was then modeled over time:

$$F_h(t) = [m \times a(t)] + F_{air}(t)$$

with F_{air} as the aerodynamic friction force to overcome during sprint running computed from sprint velocity and an estimated body frontal area and drag coefficient.[24] From the horizontal-force and sprint-velocity values, individual force–velocity relationships were determined with least-squares linear regressions.[24] F_0 and v_0 were then identified from the force–velocity relationship as the x- and y-intercepts, respectively. Maximum horizontal power output was determined as $F_0 \times v_0/4$.[17] Maximum velocity (v_{max}) was identified as the maximal velocity obtained during either 20- or 30-m sprint, respective of playing position. Optimum velocity (v_{opt}) and optimum force (F_{opt}) were identified as the levels of each respective variable (velocity and external horizontal force) at which peak power production occurred. Relative variables were determined by dividing the given absolute value by subject body mass. Intrasession test–retest reliability of all variables (v_{max}, split times, and mechanical properties) was assessed in a group of 8 recreational males before the current study under identical conditions. The study yielded intraclass correlation coefficients of .75 to .98 and coefficients of variation of 1.2% to 5.4% for all variables.

Statistical Analysis

Data are presented as mean ± SD. For practical significance, magnitude-based inferences were determined with a modified statistical Excel spreadsheet from sportsci.org.[25] We used this approach due to the clarity of application for practitioners and because traditional statistical approaches do not indicate the magnitude of effect. The following scale of magnitudes used in this study was based on methodology by Hopkins et al.[26] Effect size and 90% confidence intervals (lower limit; upper limit) were calculated to compare the difference between 2 group means. We used a default value of 0.2 as the smallest worthwhile difference as there is no current research performed in this area using a magnitude-based approach to indicate otherwise. Threshold values of 0.2, 0.6, 1.2, 2.0, and 4.0 were used to represent small, moderate, large, very large, and extremely large effects, respectively. Probabilities that differences were higher than, lower than, or similar to the smallest worthwhile difference were evaluated qualitatively as possibly, 25% to 74.9%; likely, 75% to 94.9%, very likely, 95% to 99.5%; and most (extremely) likely, >99.5%. The true difference was assessed as unclear if the chance of both higher and lower values was >5%.

Results

Athlete characteristics are shown in Table 1. Differences in age and body height were unclear between codes. Rugby union forwards were moderately heavier than rugby league forwards (ES = 1.01).

Differences in maximal sprint velocity between codes for forwards and backs were unclear (Table 2). While differences in split times between codes for forwards were unclear for all distances, rugby union backs demonstrated moderately faster times at 2 m (ES

Table 2 Maximum Sprint Velocity (v_{max}) and Timing Splits

	Rugby Union	Rugby League	ES (CI)	Inference
v_{max} (m/s)				
forwards	8.45 ± 0.54	8.43 ± 0.55	0.02 (–0.89:0.93)	Unclear
backs	9.01 ± 0.34	8.99 ± 0.28	0.06 (–0.80;0.91)	Unclear
2 m (s)				
forwards	0.73 ± 0.07	0.77 ± 0.07	0.44 (–0.47;1.35)	Unclear
backs	0.69 ± 0.05	0.75 ± 0.06	0.95 (0.11;1.78)	Moderate**
5 m (s)				
forwards	1.29 ± 0.08	1.32 ± 0.08	0.38 (–0.52;1.28)	Unclear
backs	1.23 ± 0.05	1.30 ± 0.09	0.86 (0.04;1.68)	Moderate**
10 m (s)				
forwards	2.04 ± 0.12	2.08 ± 0.08	0.37 (–0.51;1.25)	Unclear
backs	1.95 ± 0.04	2.01 ± 0.10	0.76 (–0.04;1.57)	Moderate*
20 m (s)				
forwards	3.33 ± 0.15	3.39 ± 0.11	0.46 (–0.42;1.35)	Unclear
backs	3.19 ± 0.06	3.27 ± 0.12	0.76 (–0.06;1.57)	Moderate*
30 m (s)				
forwards	—	—	—	—
backs	4.32 ± 0.09	4.39 ± 0.11	0.63 (–0.21;1.46)	Moderate*

Note: Values are mean ± SD or effect size (ES) ± 90% confidence interval (CI). v_{max} indicates maximum velocity at 20 and 30 m for forwards and backs, respectively.

*Possibly, 25–74.9%; **Likely, 75–94.9%.

= 0.95), 5 m (ES = 0.86), 10 m (ES = 0.76), 20 m (ES = 0.76), and 30 m (ES = 0.63) than rugby league backs. Effect sizes between union and league backs decreased with increasing distance (2–30 m: ES = 0.95 to 0.63) (see Figure 2). Distance covered by rugby union backs at 2 seconds (ES = 0.75) and 4 seconds (ES = 0.70) was moderately greater than in their elite league counterparts.

Differences in all mechanical properties for forwards between codes were unclear (see Table 3) with the exception of absolute F_0, which was moderately higher in rugby union (ES = 0.77). Rugby union backs displayed moderately greater relative F_0 (ES = 0.75), P_{max} (ES = 0.77), and F_{opt} (ES = 0.73), while differences in v_0 and v_{opt} were unclear.

Discussion

This is the first study, to our knowledge, to compare mechanical properties of sprint running between elite rugby codes. The playing standards for both groups used in this study were of the highest caliber available within the geographic limits of New Zealand. While we acknowledge there may be some differences in genetic makeup between varying international teams (within and between different codes), we do believe that our results would be very similar to those seen between elite codes in other nations. The main findings were that rugby union forwards were heavier in body mass than rugby league forwards, differences in maximum velocity capabilities at 20 and 30 m were unclear between codes, and rugby union backs produced greater acceleration and horizontal force than rugby league athletes.

Typically, studies measuring sprint performance in rugby code athletes have used photovoltaic cells set at distances of 5 to 40 m.[18,27] The current study included an additional shorter split distance of 2 m. The importance of such a measurement is highlighted by this short-distance split's producing the largest difference between codes (ES = 0.95). Although the difference in time appeared to decrease incrementally with increasing distance, at the 20-m mark union athletes still exhibited faster times (ES = 0.76). In a practical sense this increased acceleration means that at 2 and 4 seconds (ES = 0.75 and 0.70 respectively) during a sprint, rugby union backs would possibly be 0.44 and 0.73 m ahead of league athletes. The ability to cover a greater distance in less time could result in more ground covered throughout a competitive match and, more important, likely result in line breaks or players outflanking opposition. The differences observed over short-distance splits may illustrate acceleration over the initial sprint phase as crucial to success in rugby union. This provides a rationale for short-distance assessment being integrated into rugby union testing batteries, with consideration that the use of reliable testing methods (such as the radar method used in this study) is central to their benefit.

To accelerate during sprint running, athletes must increase their net horizontal GRF production by increasing horizontal propulsive GRF, reducing horizontal braking GRF, or a combination of the 2 methods.[7] Morin et al[6] reported that elite sprint runners are able to maintain a greater net horizontal GRF throughout a treadmill sprint acceleration from zero to top speed than are nonelite sprinters. Athletes who consistently train with a forward orientation during sprinting may improve their ability to produce a net horizontal GRF

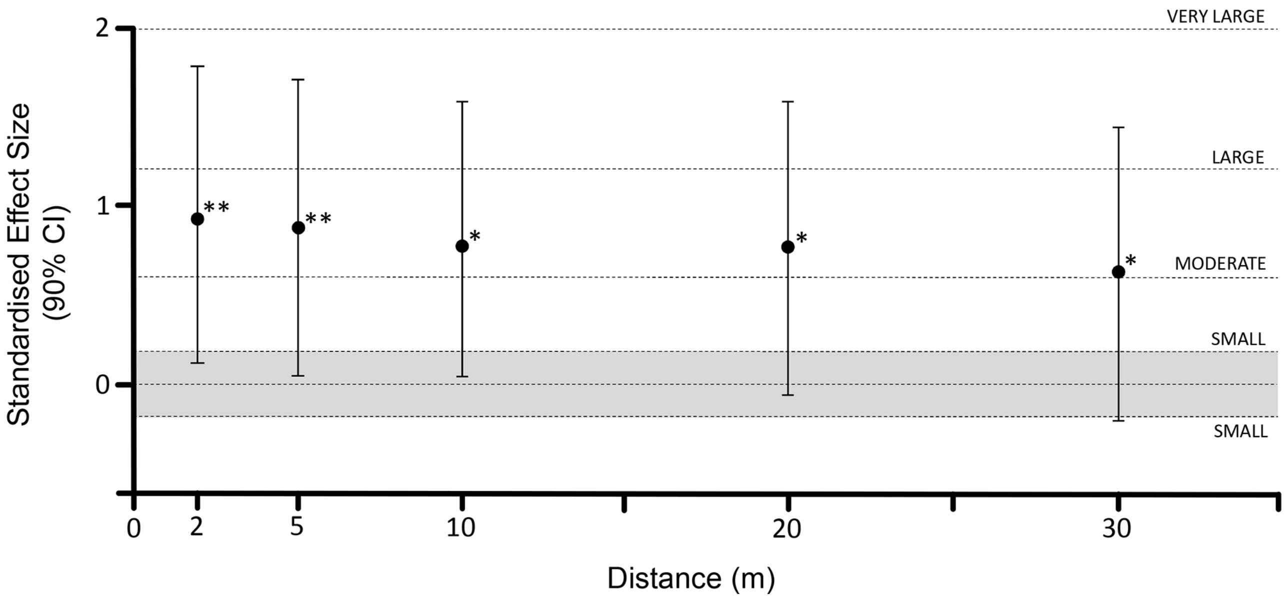

Figure 2 — An illustration of the decreasing trend of the differences between time–distance splits of rugby union and rugby league backs with increasing distance in standardized effect size with 90% confidence intervals (CI). *Possibly, 25–74.9%; **Likely, 75–94.9%.

Table 3 Mechanistic Properties of Sprinting

	Rugby Union	Rugby League	ES (CI)	Inference
v_0 (m/s)				
forwards	8.65 ± 0.59	8.66 ± 0.60	0.01 (–0.92;0.90)	Unclear
backs	9.28 ± 0.37	9.27 ± 0.31	0.03 (–0.83;0.88)	Unclear
v_{opt} (m/s)				
forwards	4.31 ± 0.29	4.31 ± 0.29	0.01 (–0.91;0.89)	Unclear
backs	4.62 ± 0.19	4.61 ± 0.15	0.04 (–0.82;0.90)	Unclear
Relative P_{max} (W/kg)				
forwards	18.3 ± 3.0	17.4 ± 1.7	0.33 (–0.55;1.21)	Unclear
backs	20.3 ± 1.0	18.9 ± 2.2	0.77 (–0.03;1.57)	Moderate*
Relative F_0 (N/kg)				
forwards	8.48 ± 1.27	8.06 ± 0.75	0.35 (–0.53;1.24)	Unclear
backs	8.76 ± 0.41	8.17 ± 0.99	0.75 (–0.06;1.55)	Moderate*
Relative F_{opt} (N/kg)				
forwards	4.24 ± 0.65	4.03 ± 0.38	0.35 (–0.54;1.23)	Unclear
backs	4.38 ± 0.22	4.09 ± 0.50	0.73 (–0.08;1.54)	Moderate*

Note: Values are mean ± SD or effect size (ES) ± 90% confidence interval (CI). All variables were generated from 20- and 30-m trials for forward and backs, respectively.

Abbreviations: v_0, theoretical maximum velocity; v_{opt}, velocity at peak power production; relative P_{max}, peak power production relative to body mass; relative F_0, theoretical maximum force relative to body mass; relative F_{opt}, force at peak power production relative to body mass.

*Possibly, 25–74.9%.

and thus improve their acceleration performance.[28] As mentioned earlier, rugby union athletes (particularly forwards) train and compete with relatively lower body orientations during tackles, rucks, scrums, and mauls. In addition, there is less distance between defenders and attackers during a typical set piece; thus, acceleration ability becomes vital. In comparison, rugby league athletes train and compete in more upright body orientations and have greater distance between defenders at the beginning of each play; therefore, athletes are more likely to have time and distance to reach higher sprinting velocities.

While forwards displayed unclear differences in most mechanical variables between union and league codes, it is interesting that this was presented under different athlete characteristics; union forwards were on average ~7.5 kg (6.7%) heavier than league forwards. Effectively this means that union forwards are able to accelerate and reach velocities comparable to their lighter league counterparts, while producing higher levels of absolute force (ES = 0.77) owing to their greater body mass. Moreover, this is important as athletes with a higher mass and similar acceleration properties will possess higher momentum ($P = m \times v$) and are more likely to overcome attacks from opposition and be harder to take down in tackles. The difference observed between forwards in the given study could be attributed to positional demands where greater instances of high-force movements (such as scrums, rucks, and mauls) favor athletes who are able to effectively accelerate greater body mass. Hence athletes who are able to produce higher absolute force are placed in an advantageous position over their lighter counterparts. Essentially, rugby union forwards in the current study were as athletic as their lighter rugby league counterparts. This notion should be interpreted with caution, however, as more mass is not necessarily advantageous without a concurrent increase in relative force output. Practitioners should consider whether the advantage of higher momentum from an increase in body mass is worth a possible decrease in acceleration ability.

Differences were observed in several mechanical variables between rugby union and league backs. Union backs presented moderately higher levels of relative F_0 (ES = 0.75) and P_{max} (ES = 0.77). It is possible that the high levels of relative F_0 and P_{max}, or effectively the ability to produce external net horizontal force relative to body mass, resulted in a likewise high level in acceleration. Previous authors[29] investigating running mechanics of maximal sprinting reported a significant correlation between initial acceleration (a_i) and mean relative horizontal power production during sprinting on a treadmill ergometer (r = .80, P < .01). Although the current study features overground sprinting rather than sprint treadmill methods,[30] there were similar findings in the current data set. Namely, high levels of relative P_{max} and relative F_0 (ES = 0.75 to 0.77) were seen in athletes (rugby union backs) exhibiting faster 2- to 20-m split times over their league counterparts. This is mechanically plausible, as external horizontal force when expressed relative to body mass (F_0/BM) is mechanically linked to acceleration ($F/m = a$). In addition, the greater horizontal force observed in rugby union athletes may be attributed to increased technical force-application ability in earlier phases of acceleration (at low velocities), while the decrease in effect size between codes with increasing splits may indicate that rugby union athletes better orient force at higher velocities.

Based on this data set, short-distance sprinting performance in elite rugby code athletes appears to be related to external horizontal force and power output measures. Thus it could be speculated that acceleration capability would benefit from a force-dominant F–v profile. This contrasts with recent research[6] examining mechanical determinants of sprinting over longer distances, where possessing a velocity-dominant F–v profile is highlighted as key to performance. It would seem from our results that sporting codes sharing similar attributes to rugby union should consider adopting a more force-dominant F–v approach to improve acceleration capabilities. Moreover, with differences appearing between these outwardly similar sporting codes, these findings serve to support the argument for an individualized approach to profiling and subsequent training in the pursuit of optimal sprinting performance.

Recently researchers[15] have suggested that hamstring function is related with horizontal force production during sprinting. Based on this, it could be speculated that greater hamstring strength could aid in the production of higher force values and greater acceleration capacity. A recent study by Brown et al[8] demonstrated that professional rugby union athletes were typically stronger in knee flexion and extension, while professional rugby league athletes were typically stronger in hip extension. Those authors theorized that the specific training and positional demands of union forwards (lower to the ground, more force-oriented movements, and eccentric and concentric stress at long hamstring muscle lengths) placed the athletes in an advantageous position to develop greater hamstring strength than league forwards. Although union backs were only marginally stronger (~15%) than league backs in the isolated knee-flexion test, it can be speculated that had testing occurred during an open-chain movement (such as sprinting) and results normalized to body mass (vs limb weight), a larger difference would have been seen. Conjunctively, these findings could help explain the higher levels of F_0 and faster short split times exhibited by union backs over their league counterparts. Further investigation into this area is warranted.

Conclusions

In this sample, differences existed in sprinting mechanics between elite rugby union and rugby league athletes. The greatest difference in sprint performance between codes was displayed at the 2-m split time and slightly decreased with increasing distance. Rugby union backs had greater relative P_{max}, F_0, and F_{opt} than rugby league backs, with the differences between forwards for the same relative variables being unclear. Higher absolute F_0 was associated with the rugby union forwards, which most likely can be attributed to their higher body mass. Measures of velocity (v_0 and v_{max}) did not distinguish between rugby codes. Despite this, at the same maximum sprinting velocity an athlete with greater body mass will possess greater momentum leading into a collision and will most likely be able to produce greater absolute force levels during acceleration. The specific body orientations used during training and competition in each code may have produced the varying levels of performance and mechanical variables seen in this study. This is speculative, however, and future researchers should consider training studies that examine the effects of orientation-specific individualized programs on mechanical sprinting profiles. This progressive approach of mechanical sprint profiling during sprinting appears sensitive enough to identify differences in athletes of different positions in rugby codes and therefore may be a useful tool for the assessment and profiling of team-sport athletes.

Practical Implications

- Rugby union athletes and coaches should consider developing a force-dominant *F–v* profile to potentially enhance acceleration capabilities, particularly over initial acceleration (<5 m).
- Rugby league athletes and coaches should consider a similar approach, in the interest of improving acceleration (and in turn speed) over short distances (2–20 m), while also considering that the ability to produce horizontal force at higher velocities may be central to success in their sport.
- Body orientation during training and competition should be considered, as this may be related to enhanced horizontal force output and acceleration ability; however, further study is warranted.
- Further studies assessing sprint performance in field-sport athletes should consider examining shorter distances (eg, 2 m) than traditionally used.

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