Anthropometric Profiles and Physical Characteristics in Competitive Female English Premiership Rugby Union Players

ABSTRACT

Rugby union is a field-based team sport with a large number of high-intensity actions such as sprinting, change of direction, tackling, scrummaging, rucking, and mauling. Competitive success in female rugby union has previously been related to anthropometric and physical characteristics, and with the recent introduction of professionalism in female rugby, characterizing such physical attributes may provide insight into selection and training processes. **Purpose:** To identify anthropometric and physical characteristics of competitive female rugby union players and differences between playing positions. **Methods:** Twenty-two players were recruited from the top tier of female rugby union in the UK during the 2018-2019 Premiership season. Players were split into forwards and backs and underwent body composition testing via dual x-ray absorptiometry (DEXA) and physical characteristic tests (10m and 20m speed, 1RM bench press and squat, countermovement jump, drop jump, isometric mid-thigh pull and 1200m shuttle). **Results:** Moderate to large significant differences between playing positions in both anthropometric and physical characteristics were found ($p < 0.01$). Forwards displayed greater body mass ($p = 0.03$), fat mass ($p = 0.01$), and absolute upper body strength ($p = 0.03$), whereas backs demonstrated superior countermovement jump height ($p = 0.01$), drop jump height ($p = 0.01$), greater reactive strength ($p = 0.03$) and speed ($p = 0.03$). **Conclusion:** These findings provide practitioners with a greater understanding of anthropometric and physical characteristics of professional female rugby union players.

Key words: female athlete, rugby, fitness, performance

INTRODUCTION

Rugby union (RU) is a field based team sport with large numbers of high-intensity actions such as; sprinting, changes of direction (CoD), tackling, scrummaging, rucking, and mauling[1,2]. Female RU has been continually growing in popularity, with over 2.2 million females playing RU in over 121 countries around the world[3]. In January 2019, the Rugby Football Union (RFU) granted 28 professional full-time contracts to the England's female international team, making them the first female rugby team in the world to go fully professional[4]. Despite the growth of female RU, there is a lack of scientific interest compared to rugby league (RL) or 7s[5].

Competitive success in female RU has previously been related to their anthropometric profile[5,6] and physical characteristics such as strength[7] and speed[8]. Due to different match-play and training demands of differing playing positions, different physical characteristics are required[1]. Forward players are involved in contact and collision situations (scrum, ruck, tackle and line out) for a greater duration and at a higher frequency than backs[1]. Compared to forwards, back players have been shown to have lower body fat and faster sprint speeds[6].

Recent literature, which focus on discussing anthropometric profiles and physical characteristics, mainly investigated female players in rugby 7s[9] or RL[10,11]. RL has no line-outs, rucks or mauls during the game and 7s and RL have less players involved on the pitch (7s: 7, RL: 13), these games create fewer stoppages and more open space, high speed demands compared to RU[12]. Therefore, the characteristics of different codes of rugby should be discussed separately due to different match demands. Studies in female RU have focused on time motion analysis[1,2], identify anthropometric profiling and physiological characteristics of specific national squads (South Africa and Scotland) [6,7], with a recent study focusing only on anthropometry in Division 1 college female rugby athletes[5]. There is, however, presently a lack of information on the characteristics in competitive female English Premiership RU players. With this in mind, the aim of this study is to identify anthropometric profiles and physical characteristics of differing playing positions for competitive female English Premiership RU players.

METHODS

Design

To identify anthropometric profiles and physical characteristics of female RU players, a cross-sectional design was used. Playing position was the independent variable and anthropometric and physical test results were the dependent variables. The following anthropometric and physical characteristics were assessed: dual-energy x-ray absorptiometry (DEXA) scan, 40m sprint, countermovement jump (CMJ), drop jump (DJ), isometric mid-thigh pull (IMTP), estimated 1 repetition maximum (1RM) for squat and bench press, and 1200 m time trial.

Participants

Twenty-two (*n* = 22) female RU players from a single team including 10 forwards (age: 26.9± 6.7 years) and 12 backs (age: 26.9± 6.7 years), volunteered for this study. Players in this study were defined as competitive because they competed in the Tyrells Premier 15's which is the highest level in English RU and won the championship in the 2018-19 season. All volunteered players had two rugby team practices and at least two individual gym sessions per week. Tests included in this study were a part of the 2019-2020 annual pre-season testing battery. Sixteen players missed the testing due to Rugby Football Union (RFU) commitments and injuries. Players did not have any existing medical conditions that compromised their participation in the study and were available for all testing sessions. This study was approved by the Ethics Research Committee of the London Sport Institute, Middlesex University and both club staff and players were informed of the benefits and risks of the investigation before signing a team approved informed consent to participate in the study.

Procedures

Data collection occurred on two separate days, day one was based in the gym and laboratory which included tests in the following order, DEXA scan, CMJ, DJ, IMTP, 1RM bench press and 1RM squat. Day two was completed 24-hours later and included field-based 40 m linear sprint (10 m and 20 m split), and 1200 m time-trial, with 20 minutes rest between each to minimize effects of fatigue. All participants refrained from intensive exercise in the 24-hour period prior to testing and any nutritional supplementation on the day of testing. At the beginning of gym and laboratory-based tests, anthropometric measurements were taken for each participant. After anthropometric measurements were taken, participants underwent a standardized warm up, consisting 10 minutes of dynamic stretching, followed by practice jumps, and testing movements were completed. Participants were familiar with all tests as they were conducted during their regular annual performance monitoring and daily training programs. Participants were informed of test procedures one week before the testing date.

Anthropometry.

Stature of each player was measured to the nearest 0.1cm using a SECA 213 stadiometer (SECA Corp, Hamburg, Germany) and body mass was measured using a SECA 703 calibrated scale (SECA Corp, Hamburg, Germany) with accuracy to the nearest 0.1 kg[6]. Body composition was measured using whole-body dual-energy x-ray absorptiometry (DEXA) (Lunar Prodigy; GE Healthcare, Madison, WI) with analysis performed using GE Encore 12.20 software (GE Healthcare). Participants were asked to wear minimal clothing (sports bra and shorts). All jewelry and metal objects were removed before each scan to improve accuracy of scan results (as per the methods of Nana et al. (2015)[13]. Variables of lean mass, fat mass, and fat percentage were recorded.

Muscular Power.

CMJ were performed on a portable force plate (Kistler type 9260AA, Winterthur, Switzerland) and data were sampled at 1000 Hz; the force plate was connected to a portable laptop that used an analysis software package (Bioware, Winterthur, Switzerland). Each participant performed a practice trial on the force plate with their hands on their hips and standing motionless for a period of 1 second prior to initiating the jump. Once familiarized with the standardized protocol, two trials were performed by each participant with three minutes rest between trials. The force plate was zeroed prior to the participant standing on the force plate between each trial. Once zeroed the participant was asked to stand on the force plate with hands on their hips where the data acquisition began. Participants were told to remain motionless for at least 1 second prior to initiating the jump to obtain bodyweight. All jumps were performed using a self-selected depth, and participants were encouraged to jump as high and as quickly as possible. All raw data was extracted as a text file and analyzed in a custom built Microsoft excel spreadsheet as outlined by Chavda et al. (2018)[14] . The detection of the initiation of the jump was calculated as the average vertical ground reaction force of the 1 second motionless period ± 5 standard deviations, minus 30ms. Jump height and modified RSI was extracted utilizing the impulse momentum method [14].

DJ were performed from a box height of 0.3 m and data was collected utilizing Optojump photoelectric cells (Microgate, Bolzano, Italy). Strict instructions were given to each participant to keep hands on hips during jumps to constrain any involvement from the upper body, avoid hopping off the box, and to avoid a tucking motion in the air i.e. legs kept straight and attempt to land in the same position as take-off. Participants were instructed to minimize ground contact time while also attempting to achieve maximal height during the DJ. Two trials were performed with three minutes rest between to avoid any residual effects of fatigue on performance. Contact time (CT), JH, and reactive strength index (RSI) were calculated by Optojump proprietary software

(Optojump Next software, version 1.9.9.0).

Muscular Strength.

Upper and lower body strength was assessed by estimated 1RM testing in the back squat followed by the bench press. To standardize testing procedures the back squat was determined as parallel when the middle of the thigh was parallel with the ground. The bench press was standardized as the bar having touched the chest. Free weights (Werksan Equipment, Ankara, Turkey) were used to perform both tests. National Strength and Conditioning Association (NSCA) guidelines[15] of repetition maximum testing was modified as follows: a specific warm-up set of given exercises of 5 repetitions were performed at ~50% 1RM followed by one set of 3 repetitions at a load corresponding to ~60-80% 1RM. Participants then performed sets of 3 repetitions with increasing weight for 3 repetition maximum (3RM) determination. 5 minutes rest was provided between each successive attempt. All 3RM determinations were made within 5 attempts. Following determination of each participant's 3RM, their 1RM was predicted using NSCA's estimate chart[15]. A minimum of 5-minute rest separated squat and bench press. Strength testing took place using free weights.

IMTP was performed on a portable force plate (Kistler type 9260AA, Winterthur, Switzerland) which was attached to a custom adjustable power rack (Absolute Performance, Cardiff, Wales) that allows fixation of a horizontal bar at any height. The bar was adjusted to a height that allowed the participants to assume a position that approximated the beginning of a second pull of the clean[16]. Knee angle was assessed using a hand-held goniometer to verify the knee angle of 125˚ ± 5˚ and a hip angle of 175˚ ± 5˚[17]. Participants hands were fixed to the bar using weightlifting straps to prevent hand movement and to ensure a maximum effort could be given without limitation of hand grip strength[17]. Each participant performed two warm up trials at 50 and 75% effort, followed by one maximal voluntary isometric contraction with 1-minute rest between each pull. The force plate was zeroed prior to the participant taking position between each trial. Once in position the participant was asked to take minimal tension on the bar and stand as still as possible. Following this a countdown was given of "3, 2, 1, Pull!", participants were verbally instructed to "pull against the bar with maximal effort as quickly as possible and push the feet down into the force plate", this instruction has been previously found to optimize peak force [18]. Two trials were performed with three minutes rest between. Net peak force, force at specific time points (200ms and 300ms) and impulse were extracted from a customized Microsoft excel spreadsheet[19] using an average of the motionless baseline plus 5 standard deviation threshold to determine the onset of initiation [18,19]. The average of the baseline was also subtracted from the absolute force time curve to provide net force.

Speed and Momentum.

Four infra-red timing gates (Brower timing systems, Utah, USA) were set at 0m and 40m on an artificial 4G rugby pitch with additional gates placed at 10m and 20m to obtain split times. Participants were instructed to start with a split stance of their preferred foot 50cm behind the first timing gate, in order to prevent any false signals of the infra-red beam. Sprint times were recorded using a wireless receiver (Brower timing systems, Utah, USA) accurate to 0.01s. Momentum was calculated by multiplying the participants' body mass by their 10m velocity[9]. Players with greater momentum can obtain an advantage, in situations which required body contact such as tackles and plays associated with scrums, rucks, and mauls[20].

Aerobic Capacity

Aerobic capacity was tested using 1200m shuttle run to determine maximal aerobic speed (MAS)[21-23]. MAS has been shown to be a valid and reliable predictor of high-intensity aerobic capacity and VO_2 max in athletes from various sports and competition-levels[21-23]. The 1200m shuttle run was executed on an artificial 4G rugby pitch. Participants performed twelve 100m shuttles accruing a total distance of 1200m.

Participants were asked to run maximally throughout to achieve best results[21]. Total time taken was recorded and MAS was calculated using the modified equations[21,23].

Participants over 100kg: MAS (m/s) = 1200 / (time in seconds – 29)

Participants less than 100kg MAS (m/s) = 1200 / (time in seconds – 20.3)

Equations were used due to heavier participants needing to carry more weight through the same distance, which causes more energy loss and effect on submaximal aerobic capacity[24]

Statistical Analyses

Participants were separated into two groups, forwards and backs. All statistics were computed using the Statistics Package for Social Sciences Version 22.0 (IBM, Armonk, United States of America). Descriptive statistics (mean ± standard deviation; 95% confidence intervals) were used to profile each variable. A Shapiro-Wilk test of normality revealed that all data were normally distributed ($p > 0.05$) (table 1 and 2). Reliability of variables was examined using a two-way intraclass correlation coefficient (ICC) with absolute agreement, coefficient of variation (CV), and standard error of the mean (SEM). Average variability taken from across both measures (ICC and CV) was interpreted as small for an ICC > 0.67 and CV < 10%, moderate when ICC < 0.67 or CV > 10%, and large when ICC < 0.67 and CV > 10% 25. Independent samples t-test was used to compare the difference between forwards and backs with statistical significance set at $p < 0.05$. Although multiple comparisons were made within each family of tests (for example anthropometry, speed, power), it was decided that a Bonferroni correction would not be applied to adjust the alpha level. This is because high-performance athletes are likely close to their genetic ceiling and sporting success can often be based on the smallest of margins. Therefore, from an applied perspective (where Type II errors are not considered to incur financial harm and/or risk injury and health), it is often preferred to risk an increase in false-positives (Type I errors) such that potentially important differences can be explored further, than tightly guard against false-negatives. Hedges effect size (g) statistic, with 95% confidence intervals were also calculated, with threshold values of < 0.25 (trivial), 0.25-0.50 (small), 0.50-1.0 (moderate), > 1.0 (large)[26,27].

**********Insert Tables 1 and 2 about here***********

RESULTS

Anthropometric profile

Results of forwards and backs mean height, body mass, lean mass, and fat mass can be found in Table 3. There was small non-significant difference in mean age (p = 0.291) and trivial non-significant difference in height (p = 0.957) between forwards and backs. Results also showed large significant differences in body mass (p = 0.030), fat percentage ($p = 0.035$) and fat mass ($p = 0.017$), but not in lean mass ($p = 0.543$).

**********Insert Tables 3 about here***********

Physical Characteristics

Comparison between forwards and backs can be found in table 4. Backs produced large significant superior 10m sprint time ($p = 0.002$), 20m ($p < 0.001$) and 1200 MAS ($p = 0.007$) than forwards. There was small non-significant difference in estimated 1RM squat ($p = 0.345$), however forwards had significantly larger estimated 1RM bench press ($p = 0.029$) than backs. For both CMJ and DJ test, backs performed moderate to large significantly better in all variables including CMJ JH ($p = 0.006$), RSImod ($p = 0.027$), DJ RSI ($p = 0.016$) and DJ JH ($p = 0.006$). Trivial to small non-significant differences were found in all IMTP measures including PF ($p = 0.361$), relative PF ($p = 0.902$), force at 200ms ($p = 0.670$), impulse at 200ms ($p = 0.663$), force at 300ms ($p = 0.736$) and impulse at 300ms ($p = 0.662$).

**********Insert Tables 4 about here***********

DISCUSSION

The aim of this study was to identify anthropometric profiles and physical characteristics between playing positions in female RU players. To the authors' knowledge, this study was the first to show respective positional characteristics of female English Premiership RU players at a competitive level. The results showed that body mass was significantly greater in forwards than backs, whereas backs were significantly quicker, with higher MAS, had greater JH, higher relative lower body strength and reactive strength than forwards.

Anthropometric differences in this study indicated forwards were significantly heavier than backs, which matches previous studies investigating the 2010 South African RU female world cup squad (forwards: 78.94 ± 13.01 ; backs: 62.97 ± 5.96 kg)[6], Division 1 Elite collegiate female RU athletes (forwards: 81.5 ± 15.1 ; backs: 64.5 ± 7.7 kg)[28] and England female RL players (forwards: 80.7 ± 14.3 ; backs: 66.0 ± 7.3 kg)[29]. However, this research goes against the findings of Nyberg and Penpraze[7], who found no significant difference in body mass between forwards (78.3 ± 9.4 kg) and backs (68.7 ± 10.1 kg) in the Scottish female RU squad. A higher body fat percentage was found in forwards when compared to backs in this study. This finding may align to forward's game demands for contact and scrum, for which excessive body fat may be a protective buffer[8]. When compared with previous studies, our findings indicate forwards in female English Premiership RU had a greater body fat percentage and higher fat mass compared to South African (30.81 ± 4.56 %)[6] and Scottish female RU squads (23.2 ± 4.9 kg)[7]. However, when making comparisons, caution should be applied given previous research[6,7] used different testing methods (BodPod and skinfolds). Although body mass is important for momentum[20], excess fat could decrease speed and power ability[8,29] and increase risk of injuries for lower body joints,[30] which suggests that forwards in this study may benefit from reducing their total body fat. However, due to lack of research in anthropometric profile in female RU, manipulation of body composition may need to be a focus in future research.

Speed is a basic requirement for intermittent team sports and is potentially a key element which can determine outcomes of a game[6]. Results of the present study indicate that backs had significantly faster 10m (forwards: 1.86 ± 0.06s ; backs: 1.79 ± 0.06s) and 20m (forwards: 3.33 ± 0.08s ; backs: 3.13 ± 0.10s) sprint time than forwards, with similar results reported in previous studies[6,29]. In the present study, only backs tested 40m (5.83 ± 0.25s) as it is unlikely forwards will engage in sprints of 40 m within a match (forwards: 10.1 ± 3.5m; backs: 26.2 ± 12.7m)[2], and backs also engaged in more high-speed running (> 20 $km \cdot h^{-1}$)[2,29]. Compared to previous studies, female English

Premiership female RU players were faster than South African female RU players across 10m (forwards: 2.08 ± 0.08s ; backs: 1.90 ± 0.07s) and 40m (5.96 ± 0.19s)[6]. Female English Premiership RU players were also faster than female Scottish RU players across 10m (forwards and backs: 2.1 ± 0.1s) and 40m (6.8 ± 0.5s)[7]. When comparing to competitive 7s backs (10m: 1.81 ± 0.03s ; 40m: 5.60 ± 0.14s)[31], Female English Premiership RU backs had faster 10m but slower 40m sprint time. Differences in 40m sprint times compared to 7s may be due to the match demands of 7s, which require longer sprint distances[31]. However, no research in female RU was found to compare the 20m results in this study.

Momentum has been suggested to be a key determinant of success in contact phases of rugby union[32]. Female players competing at high levels (especially forwards) have higher sprint momentum when compared to female players competing at lower levels [9,20]. Similar trends were found in female English Premiership RU players, however, there was no significant difference between forwards and backs which may be due to forwards reporting significantly higher body mass (p = 0.030), but significantly slower speed (p < 0.002). Speed and body mass were both necessary for building momentum; therefore, our findings suggest that forwards in this study may benefit by increasing their speed to support the game demands of high intensity running and facing collisions.

Forwards had significantly greater levels of absolute upper body strength when compared with backs, likely due to strength related movements during a game, such as scrummaging, rucking and mauling[33]. The result of this study differs from Hene et al. [6], who showed no significant difference between forwards and backs in absolute 1RM bench press (63.57 ± 15.86 vs. 55.79 ± 9.17 kg). However, both this study and Hene et al. [6] showed no significant difference between relative 1RM bench press. For lower body strength, backs performed significantly heavier relative 1RM squats ($p = 0.010$). Research has shown athletes with higher relative strength (kg / body mass) have a better ability to perform repeated intense exercise[34], reduce injury risk[34] and better acceleration performance[35]. Players in this study had an average lower body relative strength above body mass (1.2*body mass) and average upper body relative strength lower than body mass (0.86*body mass). Therefore, strength and conditioning (S&C) practitioners may wish to consider prioritizing prescribing a strength training program to improve relative strength in both forwards and backs to support their performance and reduce any potential risk of injury.

Vertical jump values have been shown to have strong relationship with speed and change of direction performance[29]. This study indicated that backs had significantly higher mean vertical jump values than forwards. Backs showed significantly higher JH in both CMJ ($p = 0.006$) and DJ ($p = 0.006$), higher RSImod during CMJ ($p = 0.027$), and higher RSI during DJ ($p = 0.016$). Similar results were found in female RU[6] and RL[29], where backs jumped higher and had higher RSI compared to forwards. When comparing results with previous studies, forwards and backs both jumped slightly higher in CMJ JH, and higher RSI than female RL players[29]. When comparing to university female RU players[36], the collegiate athletes performed higher CMJ and DJ JH, which may be due to a number of participants having competed at an international level, and thus exposed to more rigorous S&C training. No further comparisons could be made, given the study did not mention the position they tested[36]. In order to compare the study of Hene et al.[6], who used different jump assessment technology (Kistler force plate vs. Vertec jump tester), a regression equation by Petushek et al.[37] was used. The result showed female RU female players within this study had higher CMJ JH compared to those presented by Hene et al.[6]. However, when making any comparisons between vertical jump performance outcomes, the difference in assessment technology will impact the method of variable calculation which might cause different results[6,8]. Therefore, caution must be taken when interpreting and comparing different studies.

For the IMTP test, there were no significant differences in absolute force, relative force and impulse at different time points between forwards and backs. Studies have shown higher muscle mass can affect force production during IMTP test[38], which may be reasonable due to forwards in this study showing no significant difference in lean mass, higher fat mass, lower body strength, and produce lower CMJ and DJ JH and RSImod when comparing to backs. S&C practitioners should look to prescribe forwards' program with focus on increasing lean mass and force output to benefit forwards' speed, power, and repeated high intensity work, which are still pivotal to game demands. IMTP testing has shown strong relationships with performance such as strength, agility and sprint performance[16,39]. This is also a useful way to monitor athletes and is more practical because of the number of players and tight schedule of training [16,39]. This is the first study to use IMTP as muscular strength testing in female RU players. Furthermore, to the authors' knowledge, no studies have investigated the association between IMTP and rugby specific performance, such as scrummaging. Despite maximal force output being the goal during the IMTP and scrummaging, the IMTP test protocol was set up as a weightlifting specific position (120˚ knee, 175˚ hip) [17] in the present study, with joint angles differing to the position players are in during scrummaging (117˚ ± 5˚ knee, 100˚ ± 11˚ hip)[40,41]. Future research may wish to consider using comparable joint angles during the IMTP to scrummaging, in order to determine position-specific strength characteristics.

In this study, backs showed significantly faster MAS (4.18 ± 0.44 m/s) during the 1200m shuttle ($p = 0.007$) than forwards (3.63 ± 0.42 m/s). Similar results were found when comparing match distance and MAS scores, in which backs were shown to have higher MAS than forwards and cover more total distance during a match[22]. However, previous studies in female RU[6], RL[29] and 7s,[9] showed no significant difference between forwards and backs in aerobic capacity. The difference might be caused by different research methods, given Nyberg and Penpraze[7] and Jones et al.[29] used the Yo-Yo Endurance test, and Hene et al.[6] used a progressive multistage shuttle run. All other methods were short distance with rest in between. However, the 1200m shuttle was continuous running with a change of direction every 100m, which might cause a disadvantage for forwards who carry higher body mass. Time-motion studies[1,2] conducted in female RU determined that short but intensive bouts of exercise was the predominant form of anaerobic activity performed during a match. Though aerobic metabolic pathways are important for both anaerobic capacity and recovery[7], further research should also focus on anaerobic capacity tests to provide a better understanding of physical characteristics in female RU.

In summary, this study was the first to provide a comprehensive profile of anthropometric and physical characteristics in female English Premiership RU players, along with reported position-specific data. However, some limitations must also be noted. The testing schedule was during the club's pre-season, despite 9 players injured, 7 players from the club were in the 2019 international squad and had individualized training programs scheduled and were not available for testing. The addition of these players potentially provides a greater understanding of characteristics as a competitive group. Secondly, the total number of athletes and thus the number per positional group was restricted, such that the squad could not be separated into more detailed positional analysis. Lastly, participants were from one female rugby club, and thus some caution is advised when inferring this data to the wider population of English Premiership players. More studies should focus on anthropometric and physical characteristics in female RU players at different levels and positions, to identify position-specific characteristics and benchmarks. This would allow practitioners to make informed recruitment and training decisions.

PRACTICAL APPLICATIONS

This study provides valuable data derived from a sample of competitive female Premiership RU players, which allows for comparison of this under-researched population. Due to position-specific demands of rugby union, characteristics from the present study can help coaches identify positional characteristics and to use these as recruitment and training benchmarks. Furthermore, these tests can be used for monitoring tools for training and nutritional goals.

CONCLUSION

In conclusion, this is the first study to report anthropometric and physical characteristics in female English Premiership RU players. There were significant differences among forwards and backs in both anthropometric and physical characteristics measurements. The results of this study showed forwards and backs in female RU differ in both anthropometric and physical characteristics, suggesting that forwards are heavier, and backs are faster in 10 and 20m, relatively stronger, and aerobically fitter. The findings of positional differences in anthropometric and physical characteristics identify position specific strength, conditioning and speed programs a potential area of opportunity to improve female RU players.

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Table 1. Between-trial reliability for forwards physical measures

	Mean ± SD	CV (%)	ICC (95%CI)	Average variability	SEM
10m (s)	1.86 ± 0.06	0.95 (0.53 to 1.37)	0.867 (0.546 to 0.965)	small	0.02
10m momentum (kg.m.s^{-1})	432.67 ± 66.58	0.95 (0.53 to 1.37)	0.994 (0.978 to 0.999)	small	21.06
20m (s)	3.33 ± 0.08	0.90 (0.51 to 1.29)	0.768 (0.329 to 0.936)	small	0.03
CMJ JH (cm)	24.10 ± 3.14	2.14 (1.20 to 3.08)	0.894 (0.641 to 0.972)	small	0.99
CMJ RSImod (m.s^{-1})	0.40 ± 0.05	8.53 (4.79 to 12.27)	0.571 (-0.560 to 0.873)	moderate	0.02
DJ JH (cm)	24.53 ± 3.38	4.76 (2.67 to 6.85)	0.838 (0.488 to 0.957)	small	1.07
DJ CT (s)	0.21 ± 0.05	7.86 (4.42 to 11.30)	0.746 (0.240 to 0.931)	small	0.01
DJ RSI	1.16 ± 0.30	7.56 (4.25 to 10.87)	0.853 (0.508 to 0.962)	small	0.10
IMTP PF (N)	1426.20 ± 336.31	6.72 (3.77 to 9.67)	0.869 (0.577 to 0.965)	small	106.35
IMTP Relative PF (N)	18.48 ± 6.21	6.72 (3.77 to 9.67)	0.912 (0.698 to 0.977)	small	1.96
IMTP 200ms force (N)	882.23 ± 268.91	13.69 (7.69 to 19.69)	0.820 (0.435 to 0.952)	moderate	85.04
IMTP 200ms impulse (N.s)	93.60 ± 37.21	18.15 (10.20 to 26.10)	0.800 (0.372 to 0.947)	moderate	11.77
IMTP 300ms force (N)	1028.10 ± 248.19	7.79 (4.38 to 11.20)	0.838 (0.478 to 0.957)	small	78.49
IMTP 300ms impulse (N.s)	190.10 ± 59.93	12.88 (7.24 to 18.52)	0.819 (0.423 to 0.952)	moderate	18.95

CV = coefficient of variations; ICC = intra-class correlation coefficient; CI = confidence interval; CMJ = countermovement jump; JH = jump height; RSImod = modified reactive strength index; DJ RSI = drop jump reactive strength index; IMTP = isometric mid-thigh pull; PF = peak force; SEM = standard error mean. Average variability: small (ICC>0.67, CV<10%), moderate (ICC<0.67 or CV>10%) and large (ICC<0.67, CV>10%)

Table 2. Between trials reliability for backs physical measures

	Mean ± SD	**CV (%)**	**ICC (95%CI)**	**Average variability**	**SEM**
10m (s)	1.78 ± 0.05	1.44 (0.86 to 2.02)	0.741 (0.336 to 0.917)	small	0.02
10m momentum (kg.m.s^{-1})	392.38 ± 33.11	1.44 (0.86 to 2.02)	0.963 (0.880 to 0.989)	small	9.56
20m (s)	3.13 ± 0.10	1.01 (0.61 to 1.41)	0.836 (0.541 to 0.949)	small	0.03
40m (s)	5.83 ± 0.25	0.75 (0.45 to 1.05)	0.947 (0.815 to 0.985)	small	0.07
CMJ JH (cm)	30.4 2± 5.74	1.31 (0.79 to 1.83)	0.988 (0.961 to 0.997)	small	1.66
CMJ RSImod (m.s^{-1})	0.47 ± 0.08	3.25 (1.95 to 4.55)	0.912 (0.722 to 0.974)	small	0.02
DJ JH (cm)	30.85 ± 5.72	2.66 (1.60 to 3.72)	0.971 (0.903 to 0.992)	small	1.65
DJ CT (s)	0.20 ± 0.03	3.54 (2.12 to 4.96)	0.834 (0.516 to 0.950)	small	0.01
DJ RSI	1.52 ± 0.34	3.60 (2.16 to 5.04)	0.928 (0.774 to 0.979)	small	0.10
IMTP PF (N)	1260.48 ± 468.29	5.79 (3.47 to 8.11)	0.953 (0.844 to 0.986)	small	135.18
IMTP Relative PF (N)	18.13 ± 6.73	5.79 (3.47 to 8.11)	0.955 (0.852 to 0.987)	small	1.94
IMTP 200ms force (N)	831.85 ± 274.61	6.47 (3.88 to 9.06)	0.935 (0.799 to 0.981)	small	79.27
IMTP 200ms impulse (N.s)	100.58 ± 36.64	8.63 (5.18 to 12.08)	0.906 (0.707 to 0.972)	small	10.58
IMTP 300ms force (N)	988.08 ± 292.72	5.94 (3.56 to 8.32)	0.911 (0.726 to 0.973)	small	84.50
IMTP 300ms impulse (N.s)	201.25 ± 57.58	7.17 (4.30 to 10.04)	0.913 (0.728 to 0.974)	small	16.62

CV = coefficient of variations; ICC = intra-class correlation coefficient; CI = confidence interval; CMJ = countermovement jump; JH = jump height; RSImod = modified reactive strength index; DJ RSI = drop jump reactive strength index; IMTP = isometric mid-thigh pull; PF = peak force; SEM = standard error mean. Average variability: small (ICC>0.67, CV<10%), moderate (ICC<0.67 or CV>10%) and large (ICC<0.67, CV>10%)

Table 3. Anthropometric profiles and differences between forwards and backs

	Forwards	**Backs**	***p***	**Effect size (95% CI)**	**Descriptors**
Age (year)	26.9 ± 6.7	24.2 ± 4.6	0.291	0.47 (-0.38 to 1.32)	small
Height (cm)	169.0 ± 4.0	168.9 ± 5.9	0.957	0.02 (-0.82 to 0.86)	trivial
Body mass (kg)	80.4 ± 12.8	69.6 ± 6.0	0.030†	1.07 (0.18 to 1.97)	large
Fat (%)	32.4 ± 8.4	25.2 ± 6.3	0.035†	0.95 (0.06 to 1.83)	large
Fat mass (kg)	26.9 ± 10.6	17.7 ± 5.4	0.017†	1.08 (0.19 to 1.98)	large
Lean mass (kg)	50.1 ± 4.1	48.9 ± 4.9	0.543	0.25 (-0.59 to 1.10)	small

CI = confidence interval; † = significant at $p < 0.05$

Table 4. Physical profiles and difference between forwards and backs

	Forwards	**Backs**	***p***	**Effect size (95% CI)**	**Descriptors**
10m (s)	1.86 ± 0.06	1.78 ± 0.05	0.002†	1.41 (0.47 to 2.34)	large
20m (s)	3.33 ± 0.08	3.13 ± 0.10	< 0.001†	2.10 (1.06 to 3.15)	large
10m momentum ($kg.m.s^{-1}$)	432.67 ± 66.58	392.38 ± 33.11	0.080	0.76 (-0.11 to 1.63)	moderate
1200m MAS (m/s)	3.63 ± 0.42	4.18 ± 0.44	0.007†	-1.44 (-2.38 to -0.50)	large
1RM squat (kg)	88.50 ± 7.09	92.33 ± 10.70	0.345	-0.40 (-1.24 to 0.45)	small
Relative 1RM squat (kg)	1.12 ± 0.19	1.33 ± 0.15	0.010†	-1.19 (-2.10 to -0.28)	large
1RM bench press (kg)	67.5 ± 9.20	58.9 ±7.79	0.029†	0.98 (0.10 to 1.87)	large
Relative 1RM bench press (kg)	0.86 ± 0.20	0.85 ± 0.12	0.863	0.06 (-0.78 to 0.90)	trivial
CMJ JH (cm)	24.10 ± 3.14	30.42 ± 5.74	0.006†	-1.29 (-2.21 to -0.37)	large
CMJ RSImod ($m.s^{-1}$)	0.40 ± 0.05	0.47 ± 0.08	0.027†	-0.67 (-1.54 to 0.19)	moderate
DJ JH (cm)	24.53 ± 3.38	30.85 ± 5.72	0.006†	-1.26 (-2.18 to -0.35)	large
DJ CT (s)	0.21 ± 0.05	0.20 ± 0.03	0.474	0.24 (-0.60 to 1.08)	small
DJ RSI	1.16 ± 0.30	1.52 ± 0.34	0.016†	-1.15 (-2.06 to -0.25)	large
IMTP PF (N)	1426.20 ± 336.31	1260.48 ± 468.29	0.361	0.39 (-0.46 to 1.23)	small
IMTP Relative PF (N)	18.48 ± 6.21	18.13 ± 6.73	0.902	0.04 (-0.79 to 0.88)	trivial
IMTP 200ms force (N)	882.23 ± 268.91	831.85 ± 274.61	0.670	0.18 (-0.66 to 1.02)	trivial
IMTP 200ms impulse (N.s)	93.60 ± 37.21	100.58 ± 36.64	0.663	-0.18 (-1.02 to 0.66)	trivial
IMTP 300ms force (N)	1028.10 ± 248.19	988.08 ± 292.72	0.736	0.14 (-0.70 to 0.98)	trivial
IMTP 300ms impulse (N.s)	190.10 ± 59.93	201.25 ± 57.58	0.662	-0.18 (-1.02 to 0.66)	trivial

MAS = maximum aerobic speed; 1RM = 1 rep max; CMJ = countermovement jump; JH = jump height; CT = contact time; RSImod = modified reactive strength index; DJ RSI = drop jump reactive strength index; IMTP = isometric mid-thigh pull; PF = peak force; CI = confidence interval. † = significant at $p < 0.05$