International Female Rugby Union Players' Anthropometric and Physical Performance Characteristics: A Five-Year Longitudinal Analysis by Individual Positional Groups

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Word Count (excluding abstract and references): 4450

Abstract word count: 199

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Abstract

Longitudinal changes in anthropometric and physical performance characteristics of International female rugby union players were evaluated across 5-seasons, according to field position. Sixty-eight international female rugby union players from a top 2 ranked international team, undertook anthropometric and physical performance measurements across five seasons. Anthropometric and physical performance changes occurred, with skinfolds decreasing between 2015 and 2017 and body mass increasing between 2017 and 2019. Single-leg isometric squat (SL ISO), 0-10 m momentum (0-10Mom) and 20-30 m momentum (20-30Mom) were higher in 2018 and 2019 than all years. Front-row players were characterised by greater SL ISO and 1-RM bench press than inside and outside backs, with higher skinfolds and lower endurance levels than all positions. Between 2017 and 2019, front-row players had larger decreases and increases in endurance and one repetition maximum (1-RM) bench press respectively, compared to all other positions. Forwards had the highest 0-10Mom and 20-30Mom, and scrum-half the lowest, while outside backs had faster 0-10, 30-40, and 40 m (TT40 m) times, and greater peak velocity (V_{max}) compared to forward positions. These longitudinal findings show that physical performance has increased, with anthropometric and performance characteristics becoming more distinctive between positions, among elite female rugby union players.

Key Words: Women, Physical fitness, Team sport, Strength, Power, Speed

Introduction

Elite rugby union is a stochastic, intermittent field-based team sport, combining skilled actions with forceful physical contact and varying locomotion intensities, ranging from walking to sprinting (Beard et al., 2019; Cuniffe et al., 2009). The volume of intensive linear high-speed running, accelerating and decelerating appears to be greater at International standard compared to club standard (Beard et al., 2019). Accordingly, the diverse range of physical abilities required to meet the demands of the elite rugby environment, are also superior amongst elite performers compared to lesser standards of play (Argus et al., 2012; Quarrie et al., 1995; Smart et al., 2013). The advent of professionalism in the male game has resulted in longitudinal position-specific changes in physical characteristics, such as greater height and body mass and lower fat mass (Fuller et al., 2012; Hill et al., 2018). Based on findings from male rugby union, physical performance characteristics, such as strength, power, sprint speed and momentum, and endurance capacity (Argus et al., 2012; Smart et al., 2013) are also greater among professionals compared to lower-standard players. However, such physical performance determinants have not yet been reported in female rugby union. Whilst professionalism was introduced in female rugby union in 2017, with many nations currently supporting part-, and full-time training programmes, there is no longitudinal evidence of either the magnitude or type of physical adaptations among elite female players.

Differences in physical characteristics between female forwards and backs are less pronounced compared to the male game (Quarrie et al., 1995; Smart et al., 2013), and are limited to greater jump and sprint performance amongst backs, and greater total mass and fat mass amongst forwards (Hene et al., 2011; Nyberg et al., 2016). These positional differences are also less clear at lower standards, suggesting that physical performance and anthropometric characteristics in female rugby are less pronounced. This is, perhaps, due to the specialised training and selection processes at international standard (Hene et al., 2011; Nyberg et al., 2016). However, the rudimentary categorisation of players into forwards and backs positional groups may limit the current understanding of specific positional characteristics in the female game, as differences in anthropometric and physical performance characteristics between more discrete positions are evident in male rugby (Smart et al., 2011). A recent study by Posthumus et al. (2020) reported that front row and locks were heavier and had greater body fat than back row forwards within a top two World-ranked female rugby union cohort. This is presumably because of the greater demand for intensive static force production of the front five in set piece events, such as scrummaging, and suggests that more discrete positional differences are apparent at the elite-standard of female rugby. However, there have been no reports of elite female physical performance characteristics using more refined positional categorisation, which could limit both the specificity of training programmes delivered to these athletes and the early identification of developmental athletes with the innate physical potential required for elite-standard performance. Furthermore, the absence of longitudinal data, spanning the transition from amateur to professional status in elite female players, limits understanding of the impact of professionalism on physical and performance characteristics.

The aim of this study was to conduct the first longitudinal analysis of anthropometric and physical performance characteristics in elite international female rugby union players. The differences in physical characteristics were evaluated between: i) discrete field positions ii) five consecutive years of an elite female rugby program (2015-2019).

Materials & Methods

Participants

To evaluate changes in physical characteristics across time, a five-year longitudinal analysis of anthropometric and physical performance assessment scores was conducted between 2015 and 2019, using samples from an international team ranked in the top 2 nations across the study period. The team achieved world cup finalist status in 2014 and 2017. A total of 68 international female rugby union players took part across the five seasons (players observed per season; 38 ± 3), with a minimum of five international caps per player set as the inclusion criteria for an established international player (age 25 ± 4 years, stature 170.6 ± 7.0 cm, body mass 76.9 ± 9.8 kg). Due to variation in the squad personnel throughout the study, players were involved in five (n = 14), four (n = 13), three (n = 19), two (n = 14) and one (n = 8) seasons of data collection. Players undertook an extensive annual periodised physical training programme during the study period, which was prescribed by the same national Strength & Conditioning coach and delivered in collaboration with each player's domestic club practitioner. During off-season holiday periods, which accounted for approximately three-weeks of the year; players were not prescribed any formal training and did not play matches. For the remainder of the year, the approximate weekly programme consisted of strength sessions (two during international competitions, up to six during pre-season training, and approximately during domestic competition periods); conditioning sessions (zero during international competitions, approximately four during pre-season, and up to three during domestic competition depending on individual requirements); skill-based sessions (two during international competitions, five during pre-season, and approximately three during domestic competition); and rugby matches (up to two during international competitions, zero during pre-season, and one during domestic competition). During each season, a standardised battery of anthropometric and physical performance assessments was carried out three times with a total of 567 individual observations for the standardised battery of assessments (observations per season; 113 ± 7). For comparative purposes, players were grouped into six positional roles, comprising front-row forwards (FR) (n = 15), locks (L) (n = 7), back-row forwards (BR) (n = 11), scrum-halves (SH) (n = 6), inside backs (IB) (n = 13) and outside backs (OB) (n = 16). Players provided informed consent to allow data to be used for analysis purposes through their contractual agreement with the national governing body. Institutional ethics approval was granted for the study (SMEC_2018-19_057).

General procedures

Assessments were conducted at three specific points during each season, which corresponded with the ‘late physical development’ stage before major competitions (early-September, early-January, late-June). Assessments were conducted at a standardised International athletics training facility, which were consistent throughout the five seasons and were delivered by the same practitioners. The overall score for each year used in the analysis was calculated as a participant’s mean score for the assessments completed in that year.

Assessments

Players undertook anthropometric and strength and power assessment protocols in the morning between 09:30 and 12:00 and completed sprint and endurance running assessment in the afternoon between 14:30 and 16:00, with a standardised break of approximately 2.5 h between sessions. Peer and assessor verbal encouragement was given throughout all the physical performance assessments.

Body mass and skinfolds

Participants recorded their body mass before breakfast in an overnight fasted state during which only water was consumed. Participants wore shorts, vests and undergarments only, using calibrated electronic scales (Seca, London, UK). The mass of clothing was uncorrected in the final measurement. The sum of eight skinfolds (bicep, tricep, subscapular, supraspinale, suprailiac, abdomen, mid-thigh, medial calf) was measured due to this method's relative ease of delivery, low cost and consistent evidence of high reliability (Kasper et al., 2021). Skinfold thickness was taken using Harpenden calipers (British Indicators, Hertfordshire, United Kingdom) and standardised protocols according to the International Society for the Advancement of Kinanthropometry (ISAK) were implemented by the same level 3 ISAK practitioner with sampling experience of over 500 athletes, and a technical error of measurement of <2% within this elite female cohort.

Single leg isometric squat

Participants completed a general warm-up, consisting of dynamic mobility exercises, bodyweight lunges, squats and good mornings, followed by three progressive submaximal single-leg isometric pushes against a pre-loaded barbell, suspended on fixed pins in a power rack. All participants were familiarised with the assessment protocol two days before the test. Participants then performed a maximum of 3 trials of the single leg isometric squat (Hart et al., 2012), with 5 min rest between trials. The reliability of the protocol has been previously established for elite rugby players (CV <4.7% and ICC >0.96) (Hart et al., 2012). A customised power rack with integrated isometric rig and a force platform installed at floor height was used. The force platform and analysis software used between 2015 and 2016 (400-series, Ballistic Measurement System, Fitness Technology, Adelaide, Australia) differed to that used between 2017 and 2019 (FD4000, Force Decks, Vald Performance, Brisbane, Australia). Whilst the former had a lower sampling frequency (600 and 1000 Hz respectively), the variation in peak force between systems with such sampling frequency differences has been reported (CV <3.7% and ICC >0.96) (Dos Santos et al., 2016). Absolute peak force (SL ISO) and force relative to body mass (SL ISO/kgBM) were used for analysis.

Single leg drop jump

Single-leg drop jumps (SL DJ) were used to indirectly assess reactive stiffness under fast stretch-shortening cycle (SSC) conditions (Schmidtbleicher., 2002), which is associated with sprint speed and change of direction (Maloney et al., 2017). Participants hopped from a 20 cm box, with hands fixed on their hips, onto a jump mat (Kinematic Measurement Systems, Innervations, Australia), landing on the same leg from which they hopped. Upon landing participants rebounded as high as possible with minimal ground contact time (Maloney et al., 2017) and instructions were given to jump ‘high and fast’. Participants carried out 6 jumps per leg, alternating between left and right with 30 s separating each trial. The initial 3 jumps per leg was used for task familiarisation (Maloney et al., 2017) and the average of the final 3 jumps used for analysis. Trials were discarded and repeated if ground contact time was greater than 250 ms (Schmidtbleicher., 2002). The reactive strength index (RSI) was quantified by the software package automatically (Kinematic Measurement Systems, Innervations, Australia) through the division of flight (ms) time by contact time (ms) and the maximum RSI was recorded for analysis (Bishop et al., 2019). Levels of reliability for RSI have been previously reported (CV ~5%, ICC ~0.95; Beattie & Flanagan, 2015).

Counter-movement jump

Counter-movement jump peak power output (CMJ PPO) and relative power output (CMJ PPO/kg BM) were derived from jumps on a force platform (Joffe & Tallent., 2020), the reliability of which has been demonstrated (CV < 2.9% and ICC > 0.97; Markovic et al., 2004). Participants stood on a force platform (Fitness Technology, Adelaide, Australia between 2015 and 2017, and Vald Performance, Brisbane, Australia, between 2017 and 2019) with a self-selected stance width, and hands on hips to reduce contribution of the upper-body to jump outcomes (Mosier et al., 2019). Participants performed a counter-movement to a self-selected depth and jumped as high as possible, with the legs remaining straight during the flight phase, before landing with straight knees to ensure consistency of measurement (Markovic et al., 2004). A maximum of five trials, separated by 1-min rest between trials, were performed until participants achieved their highest score, which was taken for analysis.

One-repetition maximum bench press

Participant's maximum upper-body strength was assessed using a one-repetition maximum (1-RM) bench press protocol (Appleby et al., 2012, Hene et al., 2011) which has demonstrated sufficient reliability (CV ~5%, ICC ~0.94; Ritti-Dias et al., 2011; Dong-il et al., 2012). Before maximal attempts, participants carried out a progressive warm up of 10 repetitions at 60% maximum, five repetitions at 80%, three repetitions at 80% and one repetition at 90%, with a 3-min rest period between warm-up sets. A maximum of five progressive 1-RM attempts were then permitted with a minimum of five minutes rest between attempts until a 1-RM was achieved. Grip width was standardised between 150 and 200% of bi-acromial breadth for optimal performance (Wagner et al., 1992). Participants were required to maintain contact between their hips and the bench, and their feet and the floor, and to touch the barbell on their chest for each attempt to be counted. The absolute and relative weight lifted in kg (Bench 1-RM & Bench 1-RM/kg BM) was recorded for analysis.

Acceleration and peak speed

Participants performed three trials of a maximal 40 m sprint on a 110 m indoor sprint track in trainers with a minimum of 5-min rest between trials. 40m was chosen in line with previous reports for female rugby union players (Nyberg & Penpraze., 2016; Hene et al 2011) and to represent the peak sprint distances experienced in female rugby union (Suarrezz-Arrones et al., 2016). Timing gates (Brower timing systems, Utah, USA) were positioned at 0, 10, 20, 30 and 40 m, with the first gate lowered to 50 cm and the start line positioned 50 cm behind the first gate to minimise the risk of false signals (Haugen & Bucheit., 2016). Subsequent gates were set at 85 cm, or approximately hip height for this population (Cronin & Templeton., 2008; Yeadon et al., 1999). Participants initiated the sprints from a two-point stance with the front foot placed 0.5 m behind the start line. The best 40 m sprint (TT40 m) was recorded and splits for 0-10 m and 30-40 m were used to represent acceleration and maximum running ability respectively. Such split measurements are shown to be reliable (CV ~5%, Darrall-Jones et al., 2016). Before the sprints, participants performed a standardised warm-up consisting of general dynamic mobility and jogging, and progressive intensity running.

Momentum and Force-Velocity variables

Momentum was calculated for both 0-10 m (0-10 Mom) and 20-30 m (20-30 Mom) splits due to the decisive role of this variable for winning collisions (Cunningham et al., 2018; Baker & Newton., 2008). For the calculation of mechanical sprint variables, 0.5 s was added to the initial split to correct for initial triggering (Haugen et al., 2019) due to the athlete's start position being 0.5 m behind the first speed cell. This mitigated for any additional momentum that may have been built before the triggering of the sprint start as the initiation of force in propulsion and the triggering of the initial speed cell must be closely aligned as a condition for accurate F-V profiling (Morin & Samozino, 2016).

The following variables were derived from the modelling of the entire power-force-velocity relationship using a purpose-built spreadsheet (Morin & Samozino, 2016) which integrated body mass, split times and atmospheric pressure and ambient temperature set at 760 mm Hg and 17 ^{0}C, respectively. These conditions were consistent for each testing session according to the typical training and competition conditions set by the International athletics training facility. The maximum theoretical horizontal force (F_0) per unit of body mass, corresponding to the initial push off in sprint acceleration, and computed as the y-intercept of the linear F-V relationship. The maximum mechanical power output in the horizontal direction (P_{max}), referring to the apex of the Power-Velocity 2nd degree polynomial relationship. The maximum ratio of force (RF_{max}), calculated as the maximum ratio of the step averaged horizontal component of the ground reaction force to the corresponding resultant force. The rate of decline in the ratio of force with increasing speed (DRF) computed as the slope of the RF-V relationship. These variables are shown to be higher in elite sprinters due to a superior ability to efficiently apply propulsive force and have been shown to be sensitive to specific training interventions (Cahill et al., 2020; Haugen et al., 2019).

Endurance Testing

Participant's aerobic running fitness was assessed using a 1200 m continuous run on a 100 m indoor running track (12 x 100 m shuttles). This test was chosen for ease of delivery with large participant numbers, to control for adverse weather conditions and to minimise protocol time. 1200m continuous time trials, and shuttle based derivates, are demonstrated to be valid and reliable measures of aerobic running performance

(CV ~10%, ICC ~0.9), (Brew & Kelly., 2014; Swaby et al., 2016). Mean aerobic speed was calculated by dividing total distance by the time to completion in seconds (m/s).

Statistical Analysis

Linear mixed-modelling was conducted (SPSS v.22.NY.IBM Corporation) to evaluate the fixed effects of season (2015-2019) and position, consisting of front-row forwards (FR), locks (L), back-row forwards (BR), scrum-halves (SH), inside backs (IB), and outside backs (OB). The random effects were individual players for all analyses. All 24 dependant variables were analysed using separate models. Where fixed factors were significant ($p < 0.05$), *post-hoc* Bonferroni comparisons were conducted to determine differences between standards. Significance was accepted as $p < 0.05$ for all null hypothesis testing.

Results

Linear mixed modelling revealed significant effects of season for body mass ($p < 0.001$), skinfolds ($p < 0.001$), SL ISO ($p < 0.001$), SL ISO/BM ($p < 0.001$), CMJ height ($p < 0.001$) CMJ PPO ($p < 0.001$), bench press 1 RM ($p < 0.001$), 0-10 m ($p < 0.001$), 30-40 m ($p < 0.05$), TT40 m ($p < 0.001$), 0-10 Mom ($p < 0.001$), 20-30 Mom ($p < 0.001$), P_{max} ($p < 0.001$), F_0 ($p < 0.001$), RF_{max} ($p < 0.001$) and DRF ($p < 0.05$). Pairwise effects are shown in Table 1 and descriptive data is shown in tables 2 (anthropometry and strength variables), 3 (jumping and force-velocity derived variables) and 4 (sprint and endurance variables).

Effects of position were shown for body mass ($p < 0.001$), skinfolds ($p < 0.001$), SL ISO ($p < 0.001$), SL DJ ($p < 0.001$), CMJ height ($p < 0.001$), CMJ PPO/BM ($p < 0.001$), 0-10 m ($p < 0.001$), 30-40 m ($p < 0.001$) and TT40 m ($p < 0.001$), V_{max} ($p < 0.001$), 0-10 Mom ($p < 0.001$), 20-30 Mom ($p < 0.001$), F_0 ($p < 0.001$), P_{max} ($p < 0.001$), RF_{max} ($p < 0.001$) and endurance ($p < 0.001$). Pairwise effects are shown in Table 1 and descriptive data is shown in tables 2 (anthropometry and strength variables), 3 (jumping and force-velocity derived variables) and 4 (sprint and endurance variables).

There were season x position interactions for CMJ height ($p < 0.001$), bench press 1-RM/BM ($p < 0.05$), 0-10 m ($p < 0.05$), 30-40 m ($p < 0.05$), RF_{max} ($p < 0.05$), DRF ($p < 0.05$) and endurance ($p < 0.05$). Pairwise differences are shown in Tables 2 (anthropometry and strength variables), 3 (jumping and force-velocity derived variables) and 4 (sprint and endurance variables).

Insert Table 1 near here

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Discussion

The aim of the current study was to assess, for the first time, the physical characteristics of elite female rugby union players i) across time (seasons 2015-2019), and ii) between positions. The main findings of the study were that body mass, strength, power and sprint momentum increased across time, while body fat decreased. Anthropometric and physical performance characteristics were, in many cases, specific to position, and for FR and OB, positional characteristics became more distinct across time.

We show that body mass increased across time among elite female players, despite no change in stature, which agrees with previous longitudinal observations of senior international male players, transitioning between amateur and professional generations (1955 – 2015; Hill et al., 2017). However, the rate of increase across a 5-year period (~ 6.5%) amongst this elite female cohort is descriptively greater than the first 10 years following professionalism in male rugby (~ 3.8%; Hill et al., 2017).

Despite no significant position x time interactions, we also show similar trends to male rugby, whereby the rate of mass gain is descriptively fastest amongst FR and IB (11.8 and 9.1% respectively). Furthermore, skinfolds were reduced in 2016 compared to 2015 followed by a further drop in 2019. When accompanied by the overall increase in body mass, this suggests that total lean mass has increased amongst elite female players across consecutive seasons. Presumably, this is accounted for by progressive volume and specificity of training with professionalism, alongside more specific selection practices (Fuller et al., 2012; Hill et al., 2017).

Greater lean body mass can differentiate between elite and sub-elite male rugby athletes (Fontana et al., 2015; Jones et al., 2015) and is associated with the ability to win collisions due to greater momentum and perform repeated high-intensity efforts (Baker & Newton., 2008; Cunningham et al., 2018). Indeed, we also report greater 0-10 m momentum and upper-body strength, particularly amongst FR and L, in 2019 compared to any other year. This finding suggests the evolution of physical characteristics observed are highly specific to the typically high collision and contact demands of FR and L (Beard et al., 2019). The increase in momentum may be underpinned by the greater absolute leg force and power in 2019 compared to all years except 2018, whilst players maintained relative leg power and reactive leg stiffness over the five seasons. Therefore, the increase in body mass was not to the detriment of 40 m sprint performance and maximal velocity, which remained unchanged. Despite this longitudinal trend in sprint performance, a decline in initial acceleration (0-10 m), particularly among FR, L and IB, occurred between 2017 and 2018 but improved in 2019. This improvement in acceleration could be partly explained by increases in the mechanical sprint characteristics of RF_{max}, and P_{max}, suggesting that players optimised their power application during the initial sprint start, perhaps due to greater training emphasis on acceleration development during 2019.

The decline in endurance ability of FR, L and IB in the final two years of testing occurred alongside increased mass, strength and momentum profiles, particularly for FR, who's bench press performance had increased disproportionately compared to all other positions by 2019. Such specific longitudinal adaptations may represent more intensive positional demands in static contact and collision events. Furthermore, the magnitude of difference in endurance performance between positions also increased in 2018 and 2019. For example, unlike any other years, in 2019 FR showed poorer endurance performance than all positions except L, and OB were superior to all forwards positions in this regard. The IB also had greater endurance than L in 2016 and 2017, but not in 2018 or 2019. Our finding that the endurance capacity of OB was maintained and was comparable with SH is consistent with previous reports among international female players (Kirby & Riley, 1993), as well as being similar to trends reported in male rugby (Quarrie et al.,1996; Smart et al., 2013). The OB also had greater relative leg power, acceleration, peak velocity, P_{max} and RF_{max} and lower DRF values compared to all forward positions, which highlights the varied qualities required to perform as an OB in the modern female International game.

Other positional groups displayed distinctive characteristics, which would support their ability to perform specific match actions. For example, FR were stronger than all backline positions and had greater body mass, skinfolds and momentum over 10 m than all other positions, except for L, reflecting the forceful demands of the set piece, mauling and tackling actions (Duthie et al., 2003). Similar trends of greater strength and lower endurance capacity among forwards have been reported for female players (Kirby & Riley 1993). The higher body mass among FR is also consistent with male rugby players (Quarrie et al., 1996; Smart et al., 2013) and supports the high scrummaging forces necessary for this positional group (Quarrie et al., 2000).

Consistent with observations in male rugby players (Quarrie et al., 1996), SH had lower acceleration momentum than all other positions, but jumped higher than L and BR. This suggests the requirement for explosive agility to move quickly between rucks and distribute the ball effectively (Quarrie et al., 1996). Differences between L, BR and IB were less pronounced, with IB showing greater peak velocity and RF_{max} compared to L and BR, and greater SL DJ, compared to BR, whilst L had greater acceleration momentum than IB. These positional characteristics are consistent with trends in male rugby, where IB were faster than forwards (Smart et al., 2013). However, in contrast to our findings, male BR have been reported to have lower body mass and body fat composition than L (Fontana et al., 2015), whilst SH are also lighter than centres (Durandt et al., 2006). Although we show identical inter-positional trends, statistical significance was not reached, suggesting that body mass is a more homogenous physical characteristic amongst elite female players, with the exception of FR, who were heavier than all positions except L. The female game is less mature in its professional status and, subsequently, player stature may be less specialised than the male game according to positional demand (Fuller et al., 2013; Hill et al., 2017). This is noteworthy, since stature will partly determine these body mass differences (Hill et al., 2017). Furthermore, the female game is historically associated with lower kicking outputs and a tendency to attack more with the ball in hand (Hughes et al., 2017), perhaps resulting in a more continuous style of play. If this is the case, a more homogenous body shape might be expected, as reported among Seven's players, which is a rugby code characterised by a greater density of play and minimal requirement for specialised body shapes for the set-piece (Agar-Newman et al., 2015; Ross et al., 2015).

Higher relative strength and power levels among male players are associated with critical match performance indicators at elite-standard (Cunningham et al., 2019) suggesting that these physical characteristics are vital. Elite male strength athletes typically have ~25% greater relative strength and power outputs than elite females (Owens., 2011; Zupan et al., 2009). We show relative upper-body strength amongst elite females to be ~20% lower than reported for elite male rugby players (Smart et al., 2013; Appleby et al., 2016), whilst relative lower-limb force and power was ~15% lower than elite male rugby league players (Speranza et al., 2016) using similar testing methods. The larger sex discrepancy between upper-limb capabilities might have been anticipated, since female athletes have a smaller volume of their total lean tissue distributed in the upper-body compared to males (Marcovic & Sekulic, 2006). On the assumption that strength and power characteristics have similar importance among female players, we suggest that further development of relative upper-limb strength and power may provide a good return on training investment. Further research is required to understand the role of these physical characteristics on match performance.

In conclusion, we provide rugby practitioners, for the first time, with normative data of physical characteristics among international female rugby players at a positional level, and how these have changed across seasons. Changes in body composition, strength and power occurred, across the last five years, particularly amongst FR players, while endurance declined for FR, L and IB. These changes likely underpin the progression in sprint momentum and could be associated with performance during contact events and set-piece (Baker et al., 2008; Cunningham et al., 2018), and rapid speed and directional changes, which are commonplace in modern female rugby. These findings can be used to develop future normative data on some of the World's most elite female players, provide training guidance for players of different positional groups, and inform physical criteria for talent identification.

Declaration of Interest Statement

The authors report no conflict of interest. No funding was provided in support of this research.

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Table 1. Fixed effect pairwise comparisons for season and position among elite female rugby union players across five seasons.

	Season effect	**Position effect**
Stature (cm)	-	-
Body mass (kg)	[2017,2018,2019 > 2015] [2016, 2019 > 2017]	[FR,L,BR > SH,IB,OB] [FR > BR]
Skinfolds (mm)	[2016,2017,2018,2019 > 2015] [2019 > 2016]	[FR > L,BR,SH,IB,OB]
Endurance (m/s)	-	[L,BR,SH,IB,OB > FR] [OB > L]
Single leg drop jump (ft/ct)	-	[IB,OB > FR] [IB > BR]
Counter movement jump height (cm)	[2019 > 2015,2016,2017]	[OB > L,BR,IB] [SH > L,BR]
Counter movement jump peak power output (W)	[2019 > 2015,2016,2017] [2018 > 2015]	-
Counter movement jump relative peak power output (W/kg)	-	[OB > FR,L,BR]
Single leg isometric squat peak force (N)	[2016,2017,2018,2019 > 2015] [2018,2019 > 2016,2017]	[FR > SH,IB,OB] [L > SH,OB]
Single leg isometric squat relative peak force (kg/kgBM)	[2017,2018,2019 > 2015] [2018,2019 > 2016]	-
Bench press 1 repetition maximum (kg)	[2019 > 2015,2016,2017,2018]	[FR > IB,OB]
Relative bench press 1 repetition maximum (kg/kgBM)	-	[SH > L]
0-10 m sprint (s)	[2018 > 2015,2017,2019] [2016 > 2015]	[FR,L,BR > OB], [FR > IB]
30-40 m sprint (s)	[2018 > 2015]	[FR,L,BR > IB,OB] [SH > OB]
40 m sprint (s)	[2016,2017,2018 > 2015] [2018 > 2019]	[FR,L,BR > IB,OB]
Theoretical maximum velocity (m/s)	-	[OB > FR,L,BR,IB] [IB > FR,L]
0-10 momentum (kg/m/s)	[2019 > 2015,2016,2017,2018]	[FR,L,BR,IB,OB > SH] [FR,L >IB,OB] [FR > BR]
20-30 momentum (kg/m/s)	[2019 > 2015,2016,2017]	[FR,L,BR,IB,OB > SH] [FR,L > IB,OB]
Theoretical maximum force (N)	[2019 > 2016, 2018, 2017 > 2018]	[FR,L > SH,IB,OB] [BR > SH]
Theoretical maximum power (W/kg)	[2015,2017,2019 > 2018] [2015 > 2016]	[FR,L,BR > IB,OB]
Maximum ratio of force (%)	[2015,2017,2019 > 2018]	[OB > FR,L,BR] [IB > FR]
Rate of decline in the maximum ratio of force (%)	[2018 > 2017]	[OB > FR]

FR, L, SH, IB, OB denote Front row, Lock, Scrum half, Inside back, Outside back, respectively. – denotes no fixed effect found, > denotes greater than

Table 2: Interactions between season and position for anthropometry and strength variables among elite female rugby players. Pairwise comparisons show within and between-season differences for position.

		FR	L	BR	SH	IB	OB
2015	Stature (cm)	169.0 ± 4.4	180.8 ± 1.1	172.8 ± 5.4	163.8 ± 6.2	171.3 ± 5.0	167.7 ± 3.2
	Body mass (kg)	80.9 ± 5.8	84.9 ± 7.8	78.5 ± 4.5	62.5 ± 1.8	71.3 ± 7.6	66.4 ± 3.2
	Skinfolds (mm)	107.0 ± 19.5	110.9 ± 61.1	88.2 ± 18.8	84.9 ± 10.3	93.6 ± 18.3	83.0 ± 13.4
	SL ISO (N)	1830.7 ± 364.6	1885.0 ± 423.6	1737.8 ± 236.1	1616.6 ± 365.6	1761.7 ± 318.6	1688.1 ± 244.3
	SL ISO/BM (kg/kgBM)	2.39 ± 0.5	2.41 ± 0.6	2.39 ± 0.4	2.62 ± 0.6	2.58 ± 0.6	2.81 ± 0.3
	Bench 1-RM (kg)	74.7 ± 12.6$_{*\$}$	66.3 ± 10.3$_{\$}$	69.5 ± 9.4	72.7 ± 3.5	66.5 ± 6.5	66.0 ± 9.6
	Bench 1-RM/BM (kg/kgBM)	0.92 ± 0.1	0.78 ± 0.1	0.91 ± 0.2	1.15 ± 0.1	0.90 ± 0.1	0.99 ± 0.2
2016	Stature (cm)	168.7 ± 4.1	181.2 ± 0.5	172.7 ± 4.6	163.8 ± 6.2	171.8 ± 5.4	168.0 ± 3.1
	Body mass (kg)	83.7 ± 6.0	86.5 ± 4.5	79.0 ± 3.2	63.8 ± 2.3	71.7 ± 6.7	65.0 ± 2.7
	Skinfolds (mm)	114.6 ± 28.6	98.1 ± 27.9	83.6 ± 8.3	74.8 ± 9.2	82.2 ± 18.0	67.2 ± 4.3
	SL ISO (N)	2189.0 ± 256.3	2025.1 ± 337.3	2117.7 ± 249.2	1450.3 ± 120.7	1782.5 ± 210.8	1834.5 ± 295.8
	SL ISO/BM (kg/kgBM)	2.77 ± 0.4	2.37 ± 0.5	2.74 ± 0.3	2.58 ± 0.4	2.65 ± 0.4	2.88 ± 0.5
	Bench 1-RM (kg)	77.6 ± 13.2$^{ef}_{\wedge\$}$	68.5 ± 5.5$_{\wedge\$}$	72.2 ± 9.4	71.7 ± 8.0	63.0 ± 10.5^{a}	67.6 ± 9.6^{a}
	Bench 1-RM/BM (kg/kgBM)	0.92 ± 0.1	0.80 ± 0.1	0.91 ± 0.12	1.10 ± 0.1	0.84 ± 0.1	1.04 ± 0.1
2017	Stature (cm)	169.1 ± 4.1	180.4 ± 1.4	170.5 ± 4.4	166.3 ± 4.2	171.5 ± 5.5	169.5 ± 4.5
	Body mass (kg)	84.7 ± 7.1	86.5 ± 3.9	79.3 ± 2.0	64.6 ± 1.0	73.6 ± 6.1	68.3 ± 4.7
	Skinfolds (mm)	95.7 ± 19.4	93.2 ± 14.1	93.5 ± 24.3	80.0 ± 8.6	76.7 ± 13.4	72.4 ± 10.7
	SL ISO (N)	2286.3 ± 352.2	2206.3 ± 340.9	2033.3 ± 440.3	1622.8 ± 125.1	1961.8 ± 307.6	1904.7 ± 296.1
	SL ISO/BM (kg/kgBM)	2.87 ± 0.4	2.59 ± 0.4	2.60 ± 0.6	2.80 ± 0.4	2.73 ± 0.5	2.88 ± 0.6
	Bench 1-RM (kg)	85.6 ± 11.1$^{ef}_{\#\$}$	71.6 ± 5.5	70.9 ± 13.3	65.8 ± 10.1	64.0 ± 7.3^{a}	63.0 ± 9.0^{a}
	Bench 1-RM/BM (kg/kgBM)	1.01 ± 0.1	0.83 ± 0.1	0.89 ± 0.2	1.03 ± 0.2	0.88 ± 0.1	0.95 ± 0.2
2018	Stature (cm)	170.1 ± 4.4	180.7 ± 0.8	169.8 ± 5.3	161.7 ± 8.6	170.7 ± 5.6	172.1 ± 4.4
	Body mass (kg)	89.7 ± 6.1	86.6 ± 2.7	79.4 ± 2.2	64.7 ± 2.4	75.0 ± 4.9	70.3 ± 4.0
	Skinfolds (mm)	95.9 ± 13.8	92.3 ± 11.5	90.2 ± 17.5	70.7 ± 15.1	84.7 ± 7.6	77.4 ± 7.7
	SL ISO (N)	2499.3 ± 253.6	2439.5 ± 235.0	2085.5 ± 199.0	1976.1 ± 146.2	2154.0 ± 180.3	1983.5 ± 209.3
	SL ISO/BM (kg/kgBM)	2.82 ± 0.4	2.09 ± 0.2	2.55 ± 0.4	3.11 ± 0.1	2.97 ± 0.1	2.86 ± 0.4
	Bench 1-RM (kg)	85.4 ± 12.3$^{cdef}_{\#¥}$	69.9 ± 6.0	63.6 ± 5.2^{a}	69.2 ± 7.6^{a}	70.0 ± 6.1^{a}	65.4 ± 9.6^{a}
	Bench 1-RM/BM (kg/kgBM)	0.96 ± 0.1	0.81 ± 0.1	0.80 ± 0.1	1.07 ± 0.1	0.93 ± 0.0	0.93 ± 0.2
2019	Stature (cm)	170.3 ± 5.3	180.6 ± 1.0	170.3 ± 5.9	165.3 ± 5.5	172.6 ± 7.0	170.1 ± 3.1
	Body mass (kg)	91.7 ± 7.3	87.7 ± 4.7	80.8 ± 7.6	65.8 ± 1.1	78.2 ± 5.6	70.7 ± 5.0
	Skinfolds (mm)	97.1 ± 14.0	86.9 ± 10.0	83.6 ± 19.5	61.7 ± 9.8	79.1 ± 5.7	70.4 ± 6.4
	SL ISO (N)	2534.5 ± 328.1	2394.3 ± 279.2	2175.1 ± 181.0	1905.4 ± 247.0	2222.4 ± 183.5	2128.6 ± 170.9
	SL ISO/BM (kg/kgBM)	2.81 ± 0.4	2.79 ± 0.3	2.65 ± 0.5	2.98 ± 0.4	2.97 ± 0.1	3.08 ± 0.4
	Bench 1-RM (kg)	86.3 ± 11.3$^{cdef}_{\#¥*}$	73.9 ± 4.8$_{\#¥}$	71.5 ± 8.4^{a}	69.2 ± 8.3^{a}	69.4 ± 9.2^{a}	61.1 ± 6.2^{a}
	Bench 1-RM/BM (kg/kgBM)	0.94 ± 0.2	0.86 ± 0.1	0.89 ± 0.1	1.05 ± 0.1	0.89 ± 0.1	0.86 ± 0.1

FR, L, SH, IB, OB denote Front row, Lock, Scrum half, Inside back, Outside back, respectively. SL ISO = single leg isometric squat peak force, SL ISO/BM = single leg isometric squat relative peak force, Bench 1-RM = bench press 1 repetition maximum. a, b, c, d, e, f = significantly different to front row, lock, back row, scrum half, inside back, outside back respectively, within the tabulated year. #, ¥, *, ^, $ = significantly different to 2015, 2016, 2017, 2018, 2019 respectively, within the tabulated position.

Table 3: Interactions between season and position for jumping and force-velocity derived variables among elite female rugby players. Pairwise comparisons show within and between-season differences for position.

		FR	L	BR	SH	IB	OB
2015	SL DJ (ft/ct)	1.2 ± 0.3	1.1 ± 0.2	1.1 ± 0.1	1.3 ± 0.2	1.5 ± 0.3	1.4 ± 0.2
	CMJ height (cm)	30.8 ± 4.7$^{f}_{\$}$	29.0 ± 3.1^{f}	29.8 ± 1.9^{f}	35.1 ± 1.1	34.4 ± 4.6	37.9 ± 4.1^{abc}
	CMJ PPO (W)	3287.3 ± 515.4	3789.3 ± 848.5	3456.9 ± 429.2	3140.5 ± 477.3	3286.3 ± 313.1	3325.3 ± 358.3
	CMJ PPO/BM (W/kgBM)	40.8 ± 7.8	44.3 ± 7.4	44.2 ± 3.8	49.4 ± 7.7	46.4 ± 5.6	49.9 ± 6.0
	F_0 (N)	457.4 ± 34.4	461.5 ± 65.1	429.4 ± 25.1	343.1 ± 18.0	427.8 ± 47.0	385.3 ± 34.7
	P_{max} (W/kg)	11.0 ± 1.3	11.0 ± 0.4	11.8 ± 1.0	12.3 ± 0.9	13.2 ± 1.1	13.4 ± 0.9
	RF_{max} (%)	37.0 ± 2.0$^{ef}_{\wedge}$	36.0 ± 1.0	37.0 ± 2.0	38.0 ± 1.0	40.0 ± 2.0$^{a}_{\text{¥}}$	39.0 ± 2.0^{a}
	DRF (%)	-7.0 ± 0.8$^{f}_{\wedge}$	-6.6 ± 0.9	-6.1 ± 1.0	-5.8 ± 0.8	-6.4 ± 0.5	-5.9 ± 0.5^{a}
2016	SL DJ (ft/ct)	1.2 ± 0.1	1.3 ± 0.3	1.1 ± 0.2	1.3 ± 0.0	1.3 ± 0.3	1.6 ± 0.2
	CMJ height (cm)	29.4 ± 3.0^{f}	28.1 ± 4.4$^{df}_{*\wedge\$}$	29.5 ± 4.0^{f}	35.0 ± 5.5^{b}	31.5 ± 6.0	37.9 ± 5.0^{abc}
	CMJ PPO (W)	3692.6 ± 410.1	3800.2 ± 543.7	3500.9 ± 380.9	3252.8 ± 290.0	3261.6 ± 382.1	3353.7 ± 478.4
	CMJ PPO/BM (W/kgBM)	44.1 ± 4.1	44.1 ± 5.5	44.0 ± 3.8	51.0 ± 4.7	46.7 ± 6.2	51.3 ± 6.0
	F_0 (N)	466.4 ± 34.2	471.0 ± 25.0	435.1 ± 18.1	350.1 ± 14.6	386.9 ± 47.0	378.9 ± 37.0
	P_{max} (W/kg)	10.8 ± 0.8	10.7 ± 1.1	11.5 ± 0.7	11.7 ± 0.7	11.4 ± 1.6	13.6 ± 1.0
	RF_{max} (%)	36.0 ± 1.0^{f}	36.0 ± 2.0	37.0 ± 1.0	37.0 ± 1.0	36.0 ± 3.0$^{f}_{\#}$	40.0 ± 2.0^{ae}
	DRF (%)	-7.0 ± 1.0$^{e}_{\wedge}$	-6.4 ± 0.4	-6.2 ± 0.7	-6.1 ± 0.4	-5.7 ± 0.7^{a}	-6.0 ± 0.4
2017	SL DJ (ft/ct)	1.3 ± 0.3	1.2 ± 0.2	1.3 ± 0.2	1.5 ± 0.2	1.5 ± 0.2	1.5 ± 0.2
	CMJ height (cm)	32.0 ± 3.8	30.8 ± 3.4$_{\text{¥}}$	30.5 ± 3.8	33.4 ± 6.2	33.8 ± 3.2	34.2 ± 4.7$_{\wedge}$
	CMJ PPO (W)	3632.3 ± 373.5	3801.1 ± 512.7	3407.8 ± 502.1	3148.3 ± 382.1	3583.0 ± 283.3	3430.4 ± 363.1
	CMJ PPO/BM (W/kgBM)	43.2 ± 3.5	44.0 ± 5.5	42.8 ± 6.1	48.9 ± 6.2	49.0 ± 4.9	50.6 ± 3.9
	F_0 (N)	451.3 ± 48.7	453.9 ± 77.9	445.8 ± 56.3	381.7 ± 19.3	386.9 ± 47.0	401.2 ± 42.2
	P_{max} (W/kg)	10.8 ± 1.0	10.6 ± 1.4	10.9 ± 1.7	12.8 ± 0.8	11.4 ± 1.6	13.2 ± 1.1
	RF_{max} (%)	36.0 ± 1.0^{f}	35.0 ± 3.0	36.0 ± 3.0^{f}	39.0 ± 1.0	36.0 ± 3.0$^{f}_{\#}$	39.0 ± 2.0^{ac}
	DRF (%)	-6.5 ± 1.0	-6.2 ± 1.1	-7.0 ± 1.2	-6.5 ± 0.6	-5.7 ± 0.7^{a}	-6.1 ± 0.6
2018	SL DJ (ft/ct)	1.2 ± 0.1	1.2 ± 0.2	1.3 ± 0.2	1.5 ± 0.1	1.4 ± 0.2	1.5 ± 0.2
	CMJ height (cm)	31.5 ± 2.9^{df}	30.0 ± 4.1$^{df}_{\text{¥}}$	26.9 ± 3.4^{df}	43.5 ± 6.1^{abce}	31.0 ± 2.2^{df}	38.8 ± 5.1$^{abce}_{*\$}$
	CMJ PPO (W)	4094.0 ± 391.5	3663.9 ± 396.7	3379.8 ± 476.5	3438.0 ± 361.0	3328.7 ± 276.3	3781.3 ± 447.8
	CMJ PPO/BM (W/kgBM)	45.4 ± 3.3	42.7 ± 4.3	43.0 ± 6.6	51.6 ± 6.1	43.9 ± 2.6	53.7 ± 7.7
	F_0 (N)	460.6 ± 62.2	418.7 ± 33.0	390.6 ± 17.0	345.4 ± 34.6	401.5 ± 44.6	403.2 ± 36.8
	P_{max} (W/kg)	10.2 ± 1.0	9.9 ± 1.2	9.9 ± 0.8	11.4 ± 0.8	10.7 ± 1.1	13.3 ± 1.4
	RF_{max} (%)	35.0 ± 2.0$^{f}_{\#}$	34.0 ± 2.0$_{\$}$	34.0 ± 1.0^{f}	37.0 ± 1.0	36.0 ± 2.0	39.0 ± 2.0^{ac}
	DRF (%)	-6.2 ± 0.6$_{\#\text{¥}}$	-5.6 ± 0.3$_{\$}$	-5.9 ± 0.6	-5.9 ± 0.5	-6.2 ± 0.6	-5.8 ± 0.4
2019	SL DJ (ft/ct)	1.1 ± 0.2	1.2 ± 0.2	1.3 ± 0.3	1.5 ± 0.2	1.3 ± 0.2	1.5 ± 0.2
	CMJ height (cm)	32.9 ± 3.2$_{\#}$	32.1 ± 5.1$_{\text{¥}}$	32.2 ± 4.9^{f}	39.6 ± 2.9	35.2 ± 2.9	36.7 ± 3.8$^{c}_{*}$
	CMJ PPO (W)	4045.3 ± 333.4	3786.2 ± 409.4	3463.3 ± 466.7	3569.0 ± 131.3	3597.2 ± 131.3	3538.9 ± 407.7
	CMJ PPO/BM (W/kgBM)	44.5 ± 3.8	43.3 ± 4.4	42.9 ± 4.8	54.1 ± 2.7	46.2 ± 2.66	50.1 ± 5.9
	F_0 (N)	480.8 ± 62.5	504.3 ± 73.5	427.5 ± 44.6	385.4 ± 46.2	450.1 ± 50.2	415.4 ± 52.6
	P_{max} (W/kg)	10.9 ± 0.7	11.4 ± 1.2	11.3 ± 1.5	13.6 ± 1.0	12.4 ± 1.7	13.7 ± 1.1
	RF_{max} (%)	36.0 ± 1.0^{ef}	37.0 ± 2.0$_{\wedge}$	37.0 ± 3.0	40.0 ± 1.0	38.0 ± 3.0^{a}	39.0 ± 2.0^{a}
	DRF (%)	-6.3 ± 0.6	-6.9 ± 0.9$^{f}_{\wedge}$	-6.4 ± 1.0	-6.4 ± 0.6	-6.3 ± 0.7	-5.7 ± 0.6^{b}

FR, L, SH, IB, OB denote Front row, Lock, Scrum half, Inside back, Outside back, respectively. SL DJ = single leg drop jump, CMJ height = counter movement jump height, CMJ PPO = counter movement jump peak power output, CMJ PPO/BM = counter movement jump relative power output, F_0 = theoretical maximal force, P_{max} = theoretical maximal power, RF_{max} = maximal ratio of force, DRF = ratio of decline in the ratio of horizontal force. a, b, c, d, e, f = significantly different to front row, lock, back row, scrum half, inside back, outside back respectively, within the tabulated year. #, ¥, *, ^, $ = significantly different to 2015, 2016, 2017, 2018, 2019 respectively, within the tabulated position.

Table 4: Interactions between season and position for sprint, momentum and endurance variables among elite female rugby players. Pairwise comparisons show within and between-season differences for position.

		FR	L	BR	SH	IB	OB
2015	0-10 m (s)	1.93 ± 0.07$^{e}_{\wedge}$	1.95 ± 0.05$_{\wedge}$	1.9 ± 0.08	1.87 ± 0.07	1.81 ± 0.07$^{a}_{\text{¥}\wedge}$	1.81 ± 0.07
	30-40 m (s)	1.34 ± 0.12$^{ef}_{\wedge}$	1.39 ± 0.05^{ef}	1.31 ± 0.07^{ef}	1.35 ± 0.10^{f}	1.25 ± 0.11$^{abc}_{\text{¥}\$}$	1.22 ± 0.03^{abcd}
	TT40 m (s)	6.16 ± 0.39	6.18 ± 0.16	5.94 ± 0.24	5.91 ± 0.25	5.69 ± 0.24	5.60 ± 0.14
	V_{max} (m/s)	7.75 ± 0.68	8.02 ± 0.55	8.63 ± 0.89	8.97 ± 0.73	8.78 ± 0.36	9.26 ± 0.39
	0-10 mom (kg/m/s)	421.6 ± 25.4	423.9 ± 41.7	417.2 ± 19.9	334.1 ± 9.0	395.6 ± 38.9	367.6 ± 24.0
	20-30 mom (kg/m/s)	582.1 ± 38.6	588.1 ± 44.5	586.0 ± 41.5	492.2 ± 15.1	563.4 ± 56.2	541.2 ± 29.0
	Endurance (m/s)	3.8 ± 0.2^{f}	3.7 ± 0.3^{f}	4.0 ± 0.1	4.0 ± 0.2	4.0 ± 0.2	4.1 ± 0.2^{ab}
2016	0-10 m (s)	1.96 ± 0.06^{f}	1.97 ± 0.10^{f}	1.92 ± 0.04	1.92 ± 0.4	1.95 ± 0.13$^{f}_{\#}$	1.81 ± 0.07^{abe}
	30-40 m (s)	1.41 ± 0.04$^{f}_{\wedge}$	1.40 ± 0.03^{f}	1.32 ± 0.06^{f}	1.29 ± 0.10	1.31 ± 0.06$_{\#}$	1.22 ± 0.03^{abc}
	TT40 m (s)	6.27 ± 0.22	6.22 ± 0.20	5.99 ± 0.27	5.93 ± 0.17	5.97 ± 0.26	5.57 ± 0.16
	V_{max} (m/s)	7.79 ± 0.69	7.97 ± 0.30	8.54 ± 0.71	8.56 ± 0.53	8.76 ± 0.42	9.41 ± 0.21
	0-10 mom (kg/m/s)	427.5 ± 24.8	441.9 ± 20.5	415.8 ± 21.0	337.2 ± 16.9	382.4 ± 27.5	378.8 ± 57.6
	20-30 mom (kg/m/s)	588.4 ± 73.9	624.7 ± 22.9	633.2 ± 90.2	484.1 ± 31.9	567.1 ± 32.1	534.0 ± 32.3
	Endurance (m/s)	3.7 ± 0.2$^{cdef}_{\wedge}$	3.9 ± 0.4$^{e}_{\wedge}$	4.0 ± 0.1^{a}	4.1 ± 0.3^{a}	4.1 ± 0.2$^{ab}_{\#\$}$	4.1 ± 0.2^{a}
2017	0-10 m (s)	1.97 ± 0.07^{f}	2.00 ± 0.18^{e}	1.95 ± 0.11	1.84 ± 0.04	1.87 ± 0.05^{b}	1.83 ± 0.06^{a}
	30-40 m (s)	1.34 ± 0.09$^{f}_{\wedge}$	1.39 ± 0.08^{ef}	1.38 ± 0.08	1.28 ± 0.09	1.28 ± 0.05^{bc}	1.25 ± 0.05^{abc}
	TT40 m (s)	6.15 ± 0.34	6.27 ± 0.26	6.25 ± 0.39	5.79 ± 0.24	5.81 ± 0.22	5.68 ± 0.18
	V_{max} (m/s)	8.08 ± 0.90	8.10 ± 0.41	7.75 ± 0.79	8.65 ± 0.61	8.75 ± 0.69	9.07 ± 0.51
	0-10 mom (kg/m/s)	429.1 ± 31.3	435.5 ± 44.0	408.5 ± 28.6	349.9 ± 11.5	396.1 ± 29.9	375.7 ± 28.2
	20-30 mom (kg/m/s)	608.5 ± 61.0	624.6 ± 34.2	559.6 ± 45.7	489.3 ± 20.6	573.2 ± 67.1	538.8 ± 37.0
	Endurance (m/s)	3.8 ± 0.2^{ef}	3.9 ± 0.2^{ef}	3.9 ± 0.1	4.1 ± 0.0	4.0 ± 02$^{ab}_{\text{¥}}$	4.1 ± 0.2^{ab}
2018	0-10 m (s)	2.02 ± 0.08$^{f}_{\#}$	2.07 ± 0.11$^{f}_{\#\$}$	2.05 ± 0.06^{f}	1.95 ± 0.05	1.98 ± 0.08$_{\#}$	1.83 ± 0.06^{abc}
	30-40 m (s)	1.46 ± 0.12$^{df}_{\#\text{¥}*}$	1.43 ± 0.03^{f}	1.42 ± 0.06^{f}	1.32 ± 0.03^{a}	1.40 ± 0.04	1.24 ± 0.02^{abc}
	TT40 m (s)	6.44 ± 0.27	6.51 ± 0.18	6.36 ± 0.22	6.05 ± 0.09	6.29 ± 0.02	5.65 ± 0.12
	V_{max} (m/s)	7.96 ± 0.46	8.19 ± 0.49	8.03 ± 0.59	8.54 ± 0.19	8.13 ± 0.27	9.29 ± 0.56
	0-10 mom (kg/m/s)	443.8 ± 40.0	423.0 ± 25.5	387.5 ± 10.9	332.6 ± 19.9	383.8 ± 26.6	387.1 ± 27.2
	20-30 mom (kg/m/s)	632.9 ± 49.7	632.2 ± 31.5	571.1 ± 32.3	478.1 ± 9.3	552.8 ± 29.5	563.3 ± 22.0
	Endurance (m/s)	3.6 ± 0.2$^{def}_{\text{¥}}$	3.7 ± 0.$^{2df}_{\text{¥}}$	3.8 ± 0.2	4.2 ± 0.0^{ab}	4.0 ± 0.2^{a}	4.2 ± 0.2^{ab}
2019	0-10 m (s)	1.96 ± 0.06^{ef}	1.91 ± 0.12$_{\wedge}$	1.93 ± 0.10	1.80 ± 0.04	1.87 ± 0.11^{a}	1.81 ± 0.07^{a}
	30-40 m (s)	1.36 ± 0.03^{f}	1.39 ± 0.05^{f}	1.35 ± 0.10^{f}	1.34 ± 0.03^{f}	1.31 ± 0.09$^{f}_{\#}$	1.20 ± 0.04^{abcde}
	TT40 m (s)	6.12 ± 0.08	6.05 ± 0.18	6.03 ± 0.37	5.94 ± 0.10	5.82 ± 0.29	5.50 ± 0.16
	V_{max} (m/s)	8.16 ± 0.24	7.98 ± 0.38	8.27 ± 0.69	8.76 ± 0.62	8.58 ± 0.39	9.53 ± 0.39
	0-10 mom (kg/m/s)	459.3 ± 37.9	461.0 ± 40.2	404.5 ± 16.6	369.1 ± 16.7	419.6 ± 35.3	398.8 ± 33.2
	20-30 mom (kg/m/s)	653.6 ± 50.0	631.6 ± 34.6	579.6 ± 40.5	507.7 ± 36.7	588.82 ± 52.1	596.0 ± 20.0
	Endurance (m/s)	3.7 ± 0.2^{cdef}	3.7 ± 0.1^{f}	3.9 ± 0.2^{af}	4.1 ± 0.1^{a}	3.9 ± 0.2$^{a}_{\text{¥}}$	4.2 ± 0.2^{abc}

FR, L, BR, SH, IB, OB, denote Front row, Lock, Scrum half, Inside back, Outside back, respectively. , 0-10 m = sprint time from 0 to 10 m, 30-40 m = sprint time from 30 to 40 m, TT40 m = total 40 m sprint time, V_{max} = theoretical maximal velocity, 0-10 mom = average momentum from 0 to 10 m, 20-30 mon = average momentum from 20 to 30 m. a, b, c, d, e, f = significantly different to front row, lock, back row, scrum half, inside back, outside back respectively, within the tabulated year. #, ¥, *, ^, $ = significantly different to 2015, 2016, 2017, 2018, 2019 respectively, within the tabulated position.