Anthropometric, Sprint and High Intensity Running Profiles of English Academy Rugby Union Players by Position

Running Head: Anthropometric, Sprint and High Intensity Running profiles of Academy Rugby Union Players

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ABSTRACT

The purpose of the present study was to evaluate the anthropometric, sprint and high-intensity running profiles of English academy rugby union players by playing positions, and to investigate the relationships between anthropometric, sprint and high intensity running characteristics. Data was collected from 67 academy players following the off-season period and consisted of anthropometric (height, body mass, sum of 8 skinfolds [∑SF]), 40 m linear sprint (5, 10, 20 30 & 40 m splits), the Yo-Yo intermittent recovery test level 1(Yo-Yo IRTL-1) and the 30-15 intermittent fitness test (30-15IFT). Forwards displayed greater stature, body mass and ∑SF; sprint times and sprint momentum, with lower high-intensity running ability and sprint velocities than backs. Comparisons between age categories demonstrated body mass and sprint momentum to have the largest differences at consecutive age categories for forwards and backs; whilst 20-40 m sprint velocity was discriminate for forwards between Under 16s, 18s and 21s. Relationships between anthropometric, sprint velocity, momentum and high-intensity running ability demonstrated body mass to negatively impact upon sprint velocity (10 m; r = -0.34 to -0.46); positively affect sprint momentum (e.g., 5 m; r = 0.85 to 0.93), with large to very large negative relationships with the Yo-Yo IRTL-1 (r= -0.65 to -0.74) and 30-15IFT (r= -0.59 to -0.79). These findings suggest that there are distinct anthropometric, sprint and high-intensity running ability differences between and within positions in junior rugby union players. The development of sprint and high-intensity running ability may be impacted by continued increases in body mass as there appears to be a *trade-off* between momentum, velocity and the ability to complete high-intensity running.

Key Words: Rugby Union, Anthropometry, Sprinting, Speed, High Intensity Running

INTRODUCTION

Rugby union is an intermittent contact sport, characterised by high-intensity efforts followed by incomplete recovery periods (12, 22, 25). The movement patterns reflect the high-intensity nature of the sport and are characterised by accelerations, sprinting, ball carrying and tackling; interspersed with walking or jogging to reposition to further play the ball (12, 13, 15). Due to the demands of rugby union the development of aerobic capacity, speed and optimal body composition are all required to enable the optimization of training and competition across a game, season and career (14).

Playing positions in rugby union can be generalized as forwards and backs, and consist of eight and seven players respectively. Forwards are specifically involved in scrummaging and lineouts, whilst backs are primarily open field players (8). Both positions are required to participate in static exertions (rucking, mauling and tackling) to maintain or gain possession of the ball; with forwards completing a significantly larger amount of this work throughout a game (forwards 7:56 ± 1:56 mins vs. backs 1:19 ± 0:26 mins) (24). Players typically cover between 5,000 and 7,000 m (8, 23, 24) during match play dependent upon playing position and level, of which backs cover greater absolute and relative distances, and complete more of their total distance (35.4%) in sprinting compared to forwards (8).

Limited studies are available that consider the anthropometric and physiological profiles of junior rugby union players (11, 30). This is in contrast with the well documented characteristics of rugby league players from the United Kingdom (UK) (26-28) and Australia (16-18). Current research has demonstrated that anthropometric and physical characteristics develop with age in academy rugby union players (11). However, no differences were identified for sum of skinfolds (∑SF), sprint times (5, 10, 20 & 40 m) and high-intensity running ability (Yo-Yo Intermittent Recovery test Level 1 (Yo-Yo IRT-1) or 30-15 Intermittent Fitness Test (30:15IFT)) (11). (11). Positional differences have been identified in Under 19s players; with forwards demonstrating greater body mass, height and 20 and 50 m sprint time compared to backs (30). Further sprint characteristics such as velocity, momentum and acceleration were not reported.

Speed is noted as being one of many physical qualities required for success in rugby union (14, 15). Momentum has been shown to discriminate playing level in rugby league (1); develop in adolescent (Under 14s – Under 20s) rugby league players seasonally (27), and in International junior rugby union players (Under 20s) over a two year period (3). Comparisons between junior (Under 20s) and senior rugby union players demonstrate that improvements in sprint velocity and momentum can be attained over two years, with the magnitude of changes greater in the younger players, suggesting a window of adaptation in late adolescence of both sprint velocity and momentum (3). The data demonstrate very large positive correlations between body mass and sprint momentum (r = 0.92 – 0.84), and large negative correlations between body mass and sprint velocity (r = - 0.52 – -0.68) suggesting an interaction between the variables that is favourable for momentum but may hinder sprint velocity somewhat.

There are clearly differing technical, contact and running match demands between positions (8, 23, 24), as well as anthropometric and sprint positional differences (30). These, alongside the importance of speed (14, 15), momentum (1, 3, 27) and aerobic capacity (14) for performance and progression suggests that identifying positional differences in English academy rugby union players in these characteristics warrants investigation. Therefore this study was completed in two parts; part 1 evaluated within age category and between positional differences in anthropometric, sprint and high-intensity running ability. Part 2 investigated the relationships between anthropometric, sprint and high-intensity running characteristics. Understanding the differences and relationships between measures, may assist in guiding prescription of training interventions, to develop body mass, sprint capabilities or high-intensity running ability. This may allow practitioners to develop adolescent players optimally towards senior rugby, whilst allowing performance during academy rugby matchplay.

METHODS

Experimental Approach to the Problem

Junior rugby union players from a professional regional academy in the England were assessed on a range of anthropometric (height, body mass and ∑SF) and physical (5, 10, 20 & 40 m sprint, acceleration, velocity & momentum; Yo-Yo IRT-1; 30-15IFT) characteristics across 3 age categories (Under 16s, Under 18s & Under 21s) and by position (forwards and backs). This approach allowed positional comparisons of English academy rugby union within and between age categories and playing positions.

Subjects

Sixty-seven junior rugby union players from a professional regional academy in England were assessed following the off-season period (Under 16s, n = 29, forwards n = 15, backs n = 14; Under 18s, n = 24, forwards n = 12, backs n = 12; Under 21s, n = 15, forwards n = 9, backs n = 6). Anthropometric data for each squad can be found in Table 1. All players were given a training program consisting of speed, aerobic and full body resistance training during the off-season period. All experimental procedures were approved by the University ethics committee with informed and parental consent (for players under 18 years) obtained.

Procedures

Testing consisted of two sessions, performed at the beginning of pre-season. The first session consisted of anthropometric measures (height, body mass, ∑SF), 40 m linear sprint and the Yo-Yo IRTL-1 to assess high-intensity running ability. The second session was performed seven days following the first session and consisted of the 30-15IFT. Each testing session was preceded with a standardized warm-up which included jogging, dynamic movements and stretches. Tests were fully explained and demonstrated prior to assessment. Subjects were instructed to rest in the 48 hours prior to the initial testing session and to maintain normal eating and drinking habits throughout. All testing was undertaken by the lead researcher who is accredited with the United Kingdom Strength & Conditioning Association (UKSCA), except the ∑SF.

Anthropometry: Body mass and height, wearing only shorts, were measured to the nearest 0.1 kg and 0.1 cm respectively using calibrated Seca Alpha (Seca, model 220, UK) scales and Seca Alpha stadiometer. Sum of eight site skinfolds (biceps, triceps, subscapular, suprailliac, abdominal, supraspinale, front thigh and medial calf) were determined using calibrated skinfold callipers (Harpenden, British Indicators, UK) by an International Society for the Advancement of Kinanthropometry (ISAK) accredited practitioner. Practitioner intraclass correlation coefficient (ICC) and coefficient of variation (CV) had previously been calculated as $r = 0.99$ and CV = 2.9%.

Sprint time, Velocity, Acceleration & Momentum: Sprints were assessed at 5, 10, 20 and 40 m using timing gates (Brower Timing Systems, IR Emit, USA). These distances were chosen to enable assessment of initial and maximal sprint velocity and momentum as used by Barr et al. (3). Following the warm up, players completed three maximal sprints with 3 minutes rest between attempts. Each sprint was started 0.5 m behind the initial timing gate, with players instructed to start in their own time and run maximally through the final 40 m timing gate. The best of the three times was used for analysis with sprint times measured to the nearest 0.01 s. Velocity was calculated from the distance between splits divided by the change in time. Acceleration was calculated by the dividing the change in velocity by time between splits. Momentum was calculated by multiplying, between split velocity and body mass as previously used in similar populations (11). Intraclass correlation coefficient and CVs for 5, 10, 20 & 40 m sprint times were r = 0.85 and CV = 2.8%, r = 0.94 and CV = 1.4%, r = 0.90 and CV = 1.7% and r = 0.96 and CV = 1.2% respectively.

Yo-Yo Intermittent Recovery Test Level 1: The Yo-Yo IRT-1 was performed with the subjects completing 2 x 20 m shuttle runs, interspersed with 10 seconds of active recovery until volitional exhaustion. The speed of the shuttles increased as the test progressed, controlled by audio signals dictating the time in which the shuttles needed to be completed within. The speed of the test increased progressively with the players stopping of their own volition or until they missed two beeps (2). The distance ran was recorded for analysis. Previous research (21) has shown an ICC and CV for the Yo-Yo IRT-1 of r = 0.98 and CV = 4.6%.

30-15 IFT, Maximal Aerobic Speed (MAS) & Anaerobic Speed Reserve (ASR): The 30-15 IFT consisted of 30 second shuttle runs over a 40 m distance, interspersed with 15 seconds of recovery. The test begins at 8 $km \cdot hr^{-1}$ and increased by 0.5 $km \cdot hr^{-1}$ at each successive running shuttle. The speed of the test was controlled by a pre-recorded audio signal which beeped at appropriate intervals whereby players had to be within a 3 m tolerance zones at each end or the middle of the 40 m shuttle. At the end of each 30 second shuttle players were instructed to walk forwards to the nearest line, which were identified at each extremity and the middle of the shuttle at 20 m. The test was terminated when players were no longer able to maintain the imposed speed of the test or when they did not reach a 3 m tolerance zone on three consecutive occasions. The velocity from the last completed stage was noted as each players end speed for the test (4). The end speed of the test is reported to be ~ 120% v $\dot{V}O_{2MAX}$, thus allowing the calculation of speed at v$\dot{V}O_{2MAX}$ (MAS) to program running training interventions. The end speed was used to calculate the MAS of each player. Following this the ASR was then calculated by subtracting the MAS from the highest velocity calculated from the sprint split times. This was done as it has been suggested that the ASR may be a key variable to monitor to ensure optimal training intensity when prescribing supra-maximal high intensity training (5). Previous research has shown the ICC of the 30-15IFT $r = 0.96$ and CV = 1.6% (4).

Statistical Analysis

All data are presented as means ± standard deviations (*SD*) for each age category (Under 16s, Under 18s and Under 21s) by position (i.e., forwards and backs). Following log-transformation to reduce bias arising from non-uniformity error, data were analysed using magnitude based inferences (19). Within and between squad positional differences were measured to assess if measures were greater, similar or less than the smallest practical difference (SPD (0.2 x between-subject *SD*)) (20) based on Cohen's *d* effect size principle (9). The probability that the magnitude of the difference was greater than the SPD was rated as 75-95%, likely; 95-99.5%, very likely; >99.5% almost certainly. The magnitude of the difference was described as substantial when the probability of the effect being equal to or greater than the SPD (ES ≥0.2) was ≥75%; differences less than the SPD were described as trivial. Where the 90% Confidence Interval [CI] crossed both the upper and lower boundaries of the SPD (ES±0.2) the magnitude of the difference was described as unclear. To investigate the relationships between variables, Pearson's correlations were completed with thresholds for interpretation set as; <0.1 (trivial), 0.1-0.29 (small), 0.3-0.49 (moderate), 0.5-0.69 (large), 0.7-0.89 (very large) and >0.9 (extremely large) (19). This qualitative approach was taken as traditional statistics do not indicate the magnitude of an effect, which is likely to be more beneficial to practitioners in evaluating the effectiveness of training.

RESULTS

Between age category positional comparisons

Anthropometric characteristics

Between age category comparisons demonstrated forwards and backs to have greater height at U18 than U16, with U18 vs. U21 comparisons unclear. Body mass was greater at successive age categories; U16 vs. U18, and U18 vs. U21, in both forwards and backs. Under 21s demonstrated greater ∑SF in comparison to the U18 in forwards, with U18 backs having greater ∑SF in comparison to U16 (Table 1).

High-intensity running ability

Forwards demonstrated higher Yo-Yo IRTL-1 and ASR at U18 in comparison to U16, with all other comparisons unclear. All differences for Yo-Yo IRTL-1, 30-15IFT and ASR were unclear when comparing backs (Table 1).

Insert Table 1 near here

Sprint characteristics

Sprint times differed between U16 and U18 forwards at 40 m with U18 quicker, and in backs at 5 m with U18 demonstrating a slower time. Velocities derived from the differences in split times demonstrated that forwards were faster in older age groups at 5-10 m, and 20-40 m. Under 18s backs showed a lower velocity at 0-5 m, and a greater velocity at 20-40m in comparison to U16 (Table 2).

Sprint momentum in forwards was greater for older players at consecutive age groups, and similar in backs, with the exception of 0-5 m and 10-20 m in U18 vs. U21. Acceleration was greater in U18 than U21 forwards at 5-10 m and at 20-40 m, where improved acceleration was observed at consecutive age categories. Backs comparisons showed U18 to have lower acceleration capability at both 0-5 m and 5-10 m in comparison to U16, however at 20-40 m U18 demonstrated greater acceleration. Under 21s had lower acceleration at 10-20 m in comparison to U18; with greater acceleration at 20-40 m than U18 (Table 3).

Insert Table 2 near here

Insert Table 3 near here

Within age category positional comparisons

Anthropometric & high-intensity running characteristics

Within age category comparisons showed backs to have lower height, body mass and ∑SF, with greater running distance in the Yo-Yo IRTL-1 in all age categories. Backs also attained a higher 30-15IFT end speed in U16 and U18 age categories, with ASR greater in backs than forwards at U18. All other comparisons were unclear (Table 1).

Sprint characteristics

Sprint times were lower in backs than forwards for all splits in U16; 10 m, 20 m and 40 m in U18; and 40 m in U21. Backs velocities were greater than forwards at all splits in U16, 5-10 m, 10-20 m, 20-40 m in U18 and 20-40 m in U21 (Table 2).

Sprint momentum was lower in backs in comparison to forwards at every comparison. Acceleration was greater in backs at 0-5 m in U16, 5-10 m and 10-20 m in U18, with further comparisons unclear (Table 3).

Relationships

Relationships between body mass, cumulative 5 and 10 m velocity and momentum; maximal velocity and momentum, Yo-Yo IRTL-1, 30-15IFT and ASR are displayed in tables 4 (U16), 5 (U18) and 6 (U21). Very large and extremely large positive associations were identified between body mass, 5 m, 10 m, and maximal momentum for all age categories, with large to very large negative association between body mass and high intensity running ability (Yo-Yo IRTL-1 and 30-15IFT) at all age categories. Comparative velocities and momentum (i.e., 5 m velocity and 5 m momentum, 10 m velocity and 10 m momentum) demonstrated trivial to small associations. Whilst maximal velocity (Vmax) demonstrated very large negative associations at U21, large to small negative associations at U18 and trivial to small negative associations at U16 with 5 m and 10 m momentum and maximal momentum. Measures of high-intensity running ability (Yo-Yo IRTL-1 and 30-15IFT) were very largely and extremely largely positively associated at all age categories. Further large positive associations with the Yo-Yo IRTL-1 and 30-15IFT were only found with 10 m velocity in the U16, with Vmax demonstrating large association at U18 and U21. Anaerobic speed reserve was very largely positively associated with Vmax at U16 and U18 with large positive associations at U21. Further large associations with the ASR were only found at U16 age category with maximal momentum.

Insert Table 4 near here

Insert Table 5 near here

Insert Table 6 near here

DISCUSSION

Limited research (30) is available that presents the anthropometric and physical characteristics of junior rugby union players by playing position. The data in the present study demonstrate that there are clear differences between age and within age categories of anthropometric, sprinting characteristics and to some extent high-intensity running ability in both forwards and backs in academy rugby union players.

In both positional groups, body mass became greater from U16 to U21, while height differences became unclear in U18 to U21 comparisons. Continued development of body mass is likely explained the normal trajectory of growth and maturation following peak height velocity (29) which is further influenced by large increases in testosterone. Sum of skinfolds differences do not follow the same trend, as U21 forwards had higher ∑SF in comparison to U18, and U18 backs higher ∑SF in comparison to U16. It has previously been suggested that this is due to large inter-individual variation, therefore skinfolds must be monitored on an individual level (11, 28).

The uncertainty in the differences in high-intensity running ability are similar to those previously reported in rugby union (11), however the previous study only reports significant differences. The results in the current study suggest that with increased participants, an understanding of any differences between age categories may be better understood, as this would increase the confidence in the estimate of the effect (31). Greater Yo-Yo IRTL-1 and ASR were demonstrated in the forwards from U16 to U18. The Yo-Yo IRTL-1 is reported to improve with both playing level and age, therefore an increase in the test may well be expected (2). Furthermore, the ASR is likely to be greater due to the higher Vmax in U18 than U16s. Despite differences in high-intensity running ability being reported as *unclear* recent research has highlighted that when body mass is used as a covariate in the interpretation of running tests in rugby union players; those with increased body mass, attaining the same 30-15IFT score demonstrate increased high-intensity running ability (10).

Positional differences in anthropometric measures demonstrate that backs are shorter, lighter, and have lower ∑SF at each age category and is in agreement with previous research in rugby union (12). High-intensity running ability assessed via the Yo-Yo IRTL-1 was greater in the backs in comparison to the forwards at all age categories, with a trend for smaller differences with increased age. Backs also demonstrated greater 30-15IFT than forwards at U16 and U18, which further suggests backs have a higher capacity to complete high-intensity running. Backs demonstrate greater ASR than forwards at U18, which is likely influenced by the higher Vmax for backs than forwards. It has been suggested that players with a similar MAS and increased ASR are able to tolerate high-intensity exercise with less metabolic cost (5) than their counterparts; with increases in both MAS and Vmax concomitantly, improving tolerance to repeated sprint efforts (6). This may therefore have implications for training tolerance and progression, and suggests that practitioners should monitor the *locomotor profile* (i.e., MAS and Vmax) rather than high-intensity running ability and sprint velocities as separate entities.

Similar to previous research (11), suggesting absolute sprint times demonstrated no differences between age category; all comparisons were unclear with the exception of 40 m in the forwards and 5 m in the backs at U16 vs. U18. Sprint velocities from splits (i.e., 0-5 m, 5-10 m) show that forwards were faster at consecutive age groups between 5-10 m and 20-40 m. Under 16 backs sprint velocity was faster between 0-5 m and slower between 20-40 m in comparison to U18. This suggests that Vmax will increase with age in both positional groups; with recent research suggesting a window of adaptation for sprint speed during late adolescence (3).

Positional differences for sprint time and velocity demonstrate a clear trend for the backs to complete a 40 m linear sprint test in a shorter amount of time than the forwards at all splits at U16; 10, 20 and 40 m at U18; and 40 m in the U21 age category. This resulted in greater sprint velocities for the backs than forwards in all the corresponding splits, with the split where Vmax occurred being discriminate in all age categories. This suggests that Vmax should be monitored within age categories, and that maximal sprint training is necessary for future progression. Sprint momentum has previously been shown to discriminate between playing level (1, 3) and age category (11) in rugby league and rugby union. The current data support this, in that momentum was greater with moderate to large ES' across all age categories in forwards and similarly in the backs, with the exception of 0-5 m and 10-20 m at U18 and U21 comparisons. This is likely a product of the interaction of moderate to large, and moderately greater body mass for forwards and backs respectively, alongside improved sprint velocities. Acceleration demonstrated differences between consecutive age groups in both forwards and backs, with 20-40 m appearing to discriminate between age categories. Interestingly in the U16 age category, both the forwards and backs were decelerating at the 20-40 m split, suggesting that younger players attain Vmax earlier in sprinting, which has previously been reported in youth athletes (7).

Positional differences show momentum to be moderately to very largely lower for backs at all splits, and all age categories in comparison to forwards. This highlights that momentum is discriminate at each age category between positions, and can be used to identify potential players that demonstrate positional characteristics. Conversely, acceleration only demonstrated positional differences in U16 at 0-5 m and U18 at 5-10 and 10-20 m, therefore may be less useful in differentiating between positions.

The current data support that of Barr (3) who suggested that both momentum and velocity improve at a greater rate in adolescent rugby players in comparison to senior squad members. This is demonstrated by consistently greater momentum between age categories, but less so for velocity where differences between age categories are less pronounced. This suggests that momentum and velocity may not necessarily be linked.

Relationships between Vmax and 5 m, 10 m and maximal momentum for the U16 were trivial to positively small, but became negatively small to large and very large in the U18 and U21 age categories. This is somewhat in contrast to Barr (3) who reported negative moderate and small relationships between Vmax and initial (0-10 m) and maximal (30-40 m) momentum which may in part be due to combining the junior and senior playing categories for analysis. The stronger relationships observed at older age categories suggest that momentum negatively impacts upon maximal velocity, due to the expected increases in body mass following peak height velocity and resistance training (29). This further strengthens the argument that throughout a junior rugby union players' development, there is a need to train for maximal speed at all age categories to negate the impact of increases in body mass upon velocity. Body mass demonstrated large to very large negative correlations with Yo-Yo IRTL-1 and 30-15IFT at all age categories, suggesting a detrimental effect upon high-intensity running. However players with increased mass and similar end speeds in the 30-15IFT have recently been shown to have an increased capacit to complete high-intensity running (10).

In conclusion, the present study presents comparative data for positional differences in anthropometric, sprint and high intensity running ability for regional academy rugby union players at U16, U18 and U21. The findings demonstrate that height, body mass, ∑SF, high-intensity running ability, sprint time, momentum and velocity differentiate between forwards and backs at each age category. Within positional differences are primarily observed in height, body mass, momentum and acceleration, with differences in velocity and high-intensity running unclear. The findings also demonstrate the interaction between characteristics and suggest there may be a *trade-off* between momentum, velocity and the ability to complete high-intensity running. Further research is required to identify longitudinal changes in the *locomotor profile* of players over time from within a rugby union academy to understand whether there is an optimal momentum, velocity and high intensity running profile to allow performance and therefore progression. Future research should evaluate interventions aimed at increasing sprint velocity alongside increases in body mass to maximise momentum and velocity concurrently.

In order to develop a comprehensive understanding of adolescent players' physical development, cohort studies or large scale cross-sectional studies need to be undertaken. This would be greatly aided by the national governing bodies in charge of rugby union around the world standardizing testing procedures and developing centralized databases. This would allow greater analysis of characteristics at each age category, and therefore reduce comparisons that are deemed *unclear* due to large CI's associated with the effect statistic. The size of a confidence interval is influenced by sample size (31), therefore the *unclear* results in the present study do not represent similar values between age categories; rather that larger sample sizes need to be used to understand the certainty in the differences between age categories and playing position.

PRACTICAL APPLICATIONS

The present findings provide practitioners with data that allow an understanding of the differences in body mass between age categories, that these are very largely and extremely largely related to momentum, and that this negatively impacts upon velocity in older age categories. Further, the negative associations with high intensity running ability and body mass suggest that there is a *trade-off* between momentum, velocity and the absolute high intensity running. When considering the interaction between body mass, velocity, momentum and high intensity running ability, it seems that there is sufficient evidence that the *locomotor profile* should be monitored regularly, and especially when players are increasing body mass at an increased rate. This may require regular monitoring of body mass to identify periods when increases are accelerated beyond what is "normal" with linear speed testing and high intensity running ability tested at regular intervals throughout the season.

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Table 1. Anthropometric and high-intensity running characteristics of Regional Academy Rugby Union players between and within age category for forwards and backs.

	U16 Forwards (*n* = 15)	U18 Forwards (*n* = 12)	U21 Forwards (*n* = 9)	Cohen's *d* ± 90% CI and Inference U16 v U18	U18 v U21
Age (years)	15.4 ± 0.3	16.9 ± 0.5	18.9 ± 0.9	3.45 ± 0.66 U18 Almost certainly ↑	2.61 ± 0.77 U21 Almost certainly ↑
Height (cm)	181.9 ± 6.3	188.1 ± 6.2	190.1 ± 5.6	0.95 ± 0.64 U18 Very likely ↑	0.34 ± 0.73 Unclear
Body Mass (kg)	87.6 ± 8.1	93.8 ± 7.0	105.5 ± 8.5	0.80 ± 0.63 U18 Likely ↑	1.43 ± 0.74 U21 Very likely ↑
Sum of 8 skinfolds (mm)	109.7 ± 44.6	98.2 ± 20.1	119.4 ± 34.0	-0.11 ± 0.66 Unclear	0.61 ± 0.77 U21 Likely ↑
Yo-Yo IRTL1 (m)	971.4 ± 327.7	1080.0 ± 240	1142.9 ± 353.9	0.47 ± 0.66 U18 Likely ↑	0.13 ± 0.87 Unclear
30-15 IFT (km·hr^{-1})	18.0 ± 1.4	18.2 ± 1.1	18.8 ± 1.3	0.16 ± 0.70 Unclear	0.47 ± 0.83 Unclear
ASR (m·s^{-1})	3.71 ± 0.4	3.91 ± 0.4	4.01 ± 0.2	0.55 ± 0.75 U18 Likely ↑	0.32 ± 0.84 Unclear
	Backs (*n* = 14)	**Backs (*n* = 12)**	**Backs (*n* = 6)**	**U16 v U18**	**U18 v U21**
Age (years)	15.6 ±0.2	16.9 ±0.6	19.3 ± 1.2	3.14 ± 0.71 U18 Almost certainly ↑	2.32 ± 0.96 U21 Almost certainly ↑
Height (cm)	175.6 ± 6.6	178.9 ± 3.9	181.6 ± 4.4	0.57 ± 0.65 U18 Likely ↑	0.56 ± 0.86 Unclear
Body Mass (kg)	70.5 ± 10.8	78.7 ± 6.9	87.6 ± 10.7	0.91 ± 0.65 U18 Very likely ↑	0.93 ± 0.92 U21 Likely ↑
Sum of 8 skinfolds (mm)	64.2 ± 20.2	72.7 ± 12.9	84.1 ± 27.5	0.61 ± 0.73 U18 Likely ↑	0.39 ± 0.97 Unclear
Yo-Yo IRTL1 (m)	1346.6 ± 220.6	1466.6 ± 450.9	1384.0 ± 249.2	0.19 ± 0.96 Unclear	-0.10 ± 1.00 Unclear
30-15 IFT (km·hr^{-1})	18.8 ± 1.1	19.2 ± 0.98	19.4 ± 0.5	0.32 ± 0.84 Unclear	0.26 ± 1.02 Unclear
ASR (m·s^{-1})	4.01 ± 0.6	4.23 ± 0.4	4.13 ± 0.3	0.44 ± 0.79 Unclear	-0.28 ± 1.08 Unclear
	Forwards vs. Backs comparisons				
Age (years)	0.61 ± 0.61 Backs Likely ↑	0.08 ± 0.78 Unclear	0.32 ± 0.93 Unclear		
Height (cm)	-0.95 ± 0.62 Backs Very likely ↓	-1.63 ± 0.69 Backs Almost certainly ↓	-1.61 ± 0.87 Backs Very likely ↓		
Body Mass (kg)	-1.71 ± 0.62 Backs Almost certainly ↓	-2.12 ± 0.72 Backs Almost certainly ↓	-1.69 ± 0.93 Backs Very likely ↓		
Sum of 8 skinfolds (mm)	-1.26 ± 0.67 Backs Very likely ↓	-1.53 ± 0.74 Backs Almost certainly ↓	-1.02 ± 0.90 Backs Likely ↓		
Yo-Yo IRTL-1 (m)	1.33 ± 0.64 Backs Almost certainly ↑	0.96 ± 0.94 Backs Likely ↑	0.81 ± 0.94 Backs Likely ↑		
30-15 IFT (km·hr^{-1})	0.62 ± 0.69 Backs Likely ↑	0.87 ± 0.85 Backs Likely ↑	0.59 ± 0.93 Unclear		
ASR (m·s^{-1})	0.48 ± 0.74 Unclear	0.81 ± 0.88 Backs Likely ↑	0.36 ± 1.17 Unclear		

Data presented as mean (± SD) & Cohen's *d* effect size [90% confidence intervals] and qualitative descriptor describing the magnitude of the effect based upon Hopkins' criteria (19).

Table 2. Forty meter linear sprint split times, and split velocities of Regional Academy Rugby Union players between and within age category for forwards and backs.

	U16 Forwards (*n* = 15)	U18 Forwards (*n* = 12)	U21 Forwards (*n* = 9)	Cohen's *d* ± 90% CI and Inference U16 v U18	Cohen's *d* ± 90% CI and Inference U18 v U21
5 m (s)	1.09 ± 0.11	1.07 ± 0.05	1.09 ± 0.07	-0.16 ± 0.69 Unclear	0.24 ± 0.92 Unclear
10 m (s)	1.88 ± 0.12	1.84 ± 0.06	1.82 ± 0.10	-0.36 ± 0.69 Unclear	-0.22 ± 0.94 Unclear
20 m (s)	3.21 ± 0.18	3.14 ± 0.10	3.12 ± 0.11	-0.44 ± 0.66 Unclear	-0.16 ± 0.90 Unclear
40 m (s)	5.87 ± 0.30	5.63 ± 0.21	5.52 ± 0.17	-0.91 ± 0.70 U18 Very likely ↓	-0.53 ± 0.85 Unclear
0 – 5 m V (m·s^{-1})	4.65 ± 0.45	4.69 ± 0.22	4.63 ± 0.32	0.16 ± 0.69 Unclear	-0.24 ± 0.92 Unclear
5 – 10 m V (m·s^{-1})	6.34 ± 0.38	6.53 ± 0.31	6.85 ± 0.36	0.53 ± 0.71 U18 Likely ↑	0.86 ± 0.9 U21 Likely ↑
10 – 20 m V (m·s^{-1})	7.65 ± 0.35	7.68 ± 0.34	7.68 ± 0.27	0.08 ± 0.71 Unclear	0.00 ± 0.84 Unclear
20 – 40 m V (m·s^{-1})	7.48 ± 0.47	8.06 ± 0.37	8.35 ± 0.27	1.30 ± 0.7 U18 Very likely ↑	0.87 ± 0.83 U21 Likely ↑
	Backs (*n* = 14)	**Backs (*n* = 12)**	**Backs (*n* = 6)**	**U16 v U18**	**U18 v U21**
5 m (s)	1.01 ± 0.05	1.05 ± 0.04	1.05 ± 0.07	0.87 ± 0.75 U18 Likely ↑	0.03 ± 1.07 Unclear
10 m (s)	1.77 ± 0.08	1.79 ± 0.06	1.76 ± 0.12	0.28 ± 0.75 Unclear	-0.30 ± 1.07 Unclear
20 m (s)	2.99 ± 0.15	3.02 ± 0.10	3.02 ± 0.15	0.20 ± 0.72 Unclear	-0.02 ± 1.05 Unclear
40 m (s)	5.45 ± 0.31	5.34 ± 0.17	5.32 ± 0.22	-0.40 ± 0.74 Unclear	-0.08 ± 1.03 Unclear
0 – 5 m V (m·s^{-1})	4.98 ± 0.27	4.77 ± 0.17	4.77 ± 0.36	-0.87 ± 0.75 U18 Likely ↓	-0.03 ± 1.07 Unclear
5 – 10 m V (m·s^{-1})	6.63 ± 0.52	6.79 ± 0.28	7.14 ± 0.58	0.40 ± 0.73 Unclear	0.63 ± 1.08 Unclear
10 – 20 m V (m·s^{-1})	8.22 ± 0.64	8.12 ± 0.32	7.94 ± 0.38	-0.16 ± 0.72 Unclear	-0.48 ± 1.03 Unclear
20 – 40 m V (m·s^{-1})	8.16 ± 0.55	8.63 ± 0.42	8.68 ± 0.31	0.90 ± 0.75 U18 Likely ↑	0.15 ± 0.97 Unclear
	Forwards vs. Backs comparisons				
5 m (s)	-0.86 ± 0.68 Backs likely ↓	-0.41 ± 0.80 Unclear	-0.40 ± 1.03 Unclear		
10 m (s)	-0.95 ± 0.68 Backs Very likely ↓	-0.81 ± 0.83 Backs Likely ↓	-0.52 ± 1.05 Unclear		
20 m (s)	-1.27 ± 0.63 Backs Almost certainly ↓	-1.14 ± 0.82 Backs Very likely ↓	-0.69 ± 1.05 Unclear		
40 m (s)	-1.36 ± 0.68 Backs Almost certainly ↓	-1.38 ± 0.81 Backs Very likely ↓	-0.89 ± 1.05 Backs Likely ↓		
0 – 5 m V (m·s^{-1})	0.86 ± 0.68 Backs Likely ↑	0.41 ± 0.80 Unclear	0.40 ± 1.03 Unclear		
5 – 10 m V (m·s^{-1})	0.60 ± 0.68 Backs likely ↑	0.82 ± 0.81 Backs Likely ↑	0.51 ± 1.07 Unclear		
10 – 20 m V (m·s^{-1})	1.06 ± 0.68 Backs Very likely ↑	1.26 ± 0.81	0.70 ± 1.05 Unclear		

20 – 40 m V (m·s^{-1})	1.25 ± 0.68 Backs Very likely ↑	Backs Very likely ↑ 1.38 ± 0.83 Backs Very likely ↑	1.02 ± 1.03 Backs Likely ↑

Data presented as mean (± SD) & Cohen's *d* effect size [90% confidence intervals] and qualitative descriptor describing the magnitude of the effect based upon Hopkins' criteria (19).

Table 3. Forty meter linear sprint split momentum, and split acceleration of Regional Academy Rugby Union players between and within age category for forwards and backs

	U16 Forwards (*n* = 15)	U18 Forwards (*n* = 12)	U21 Forwards (*n* = 9)	Cohen's *d* ± 90% CI and Inference U16 v U18	U18 v U21
0 – 5 m Mom (kg.s^{-1})	400.5 ± 43.8	442.1 ± 29.5	484.4 ± 57.3	1.07 ± 0.70 U18 Very Likely ↑	0.82 ± 0.97 U21 Likely ↑
5 – 10 m Mom (kg.s^{-1})	547.0 ± 45.8	616.3 ± 51.2	715.6 ± 59.5	1.38 ± 0.71 U18 Very likely ↑	1.71 ± 0.88 U21 Very likely ↑
10- 20 m Mom (kg.s^{-1})	661.0 ± 62.	725.1 ± 61.9	804.0 ± 79.2	0.98 ± 0.71 U18 Very likely ↑	1.01 ± 0.90 U21 Likely ↑
20 - 40 m Mom (kg.s^{-1})	645.4 ± 64.6	759.8 ± 57.4	873.1 ± 69.1	1.78 ± 0.70 U18Almost certainly ↑	1.65 ± 0.88 U21 Very likely ↑
0 – 5 m Acc (m·s^{-2})	4.35 ± 0.82	4.41 ± 0.42	4.30 ± 0.59	0.16 ± 0.69 Unclear	-0.24 ± 0.92 Unclear
5 – 10 m Acc (m·s^{-2})	2.17 ± 0.65	2.43 ± 0.64	3.06 ± 0.61	0.39 ± 0.71 Unclear	0.96 ± 0.83 U21 Likely ↑
10 – 20 m Acc (m·s^{-2})	1.01 ± 0.36	0.89 ± 0.35	0.64 ± 0.37	-0.34 ± 0.73 Unclear	-0.54 ± 0.88 Unclear
20 – 40 m Acc (m·s^{-2})	-0.06 ± 0.22	0.15 ± 0.08	0.28 ± 0.08	1.17 ± 0.69 U18 Very likely ↑	1.54 ± 0.86 U21 Very likely ↑
	Backs (*n* = 14)	**Backs (*n* = 12)**	**Backs (*n* = 6)**	**U16 v U18**	**U18 v U21**
0 – 5 m Mom (kg.s^{-1})	343.2 ± 64.1	371.2 ± 38.4	404.9 ± 47.0	0.58 ± 0.73 U18 Likely ↑	0.72 ± 1.03 Unclear
5 – 10 m Mom (kg.s^{-1})	457.1 ± 84.7	528.0 ± 52.6	603.6 ± 46.1	0.98 ± 0.73 U18 Very likely ↑	1.44 ± 0.97 U21 Very likely ↑
10- 20 m Mom (kg.s^{-1})	567.0 ± 105.9	631.2 ± 60.5	672.2 ± 52.3	0.76 ± 0.72 U18 Likely ↑	0.70 ± 0.97 Unclear
20 - 40 m Mom (kg.s^{-1})	564.3 ± 112.6	669.4 ± 52.3	735.3 ± 53.8	1.14 ± 0.71 U18 Very likely ↑	1.16 ± 0.98 U21 Likely ↑
0 – 5 m Acc (m·s^{-2})	4.96 ± 0.55	4.56 ± 0.32	4.58 ± 0.71	-0.87 ± 0.75 U18 Likely ↓	-0.03 ± 1.07 Unclear
5 – 10 m Acc (m·s^{-2})	2.24 ± 0.93	2.75 ± 0.44	3.42 ± 0.92	0.83 ± 0.71 U18 Likely ↓	0.68 ± 1.08 Unclear
10 – 20 m Acc (m·s^{-2})	1.34 ± 0.60	1.08 ± 0.32	0.64 ± 0.46	-0.18 ± 0.71 Unclear	-1.01 ± 1.05 U21 Likely ↓
20 – 40 m Acc (m·s^{-2})	-0.02 ± 0.27	0.22 ± 0.13	0.32 ± 0.10	1.08 ± 0.72 U18 Very likely ↑	0.81 ± 0.97 U21 Likely ↑
	Forwards vs. Backs comparisons				
0 – 5 m Mom (kg.s^{-1})	-1.05 ± 0.68 Backs Very likely↓	-1.93 ± 0.87 Backs Almost certainly ↓	-1.39 ± 1.03 Backs Very likely ↓		
5 – 10 m Mom (kg.s^{-1})	-1.25 ± 0.68 Backs Very likely ↓	-1.61 ± 0.85 Backs Very likely ↓	-1.98 ± 1.03 Backs Very likely ↓		
10- 20 m Mom (kg.s^{-1})	-1.06 ± 0.68 Backs Very likely ↓	-1.43 ± 0.84 Backs Very likely ↓	-1.82 ± 1.01 Backs Very likely ↓		
20 - 40 m Mom (kg.s^{-1})	-0.88 ± 0.68 Backs Very likely ↓	-1.52 ± 0.83 Backs Very likely ↓	-2.06 ± 1.02 Backs Almost certainly ↓		
0 – 5 m Acc (m·s^{-2})	0.86 ± 0.68 Backs Likely ↑	0.41 ± 0.80 Unclear	0.40 ± 1.03 Unclear		
5 – 10 m Acc (m·s^{-2})	0.00 ± 0.68 Unclear	0.61 ± 0.78 Backs Likely ↑	0.32 ± 1.07 Unclear		

10 – 20 m Acc (m·s^{-2})	0.34 ± 0.68 Unclear	0.56 ± 0.77 Backs Likely ↑	-0.01 ± 1.05 Unclear
20 – 40 m Acc (m·s^{-2})	0.14 ± 0.63 Unclear	0.59 ± 0.87 Unclear	0.44 ± 1.03 Unclear

Data presented as mean (± SD) & Cohen's *d* effect size [90% confidence intervals] and qualitative descriptor describing the magnitude of the effect based upon Hopkins' criteria (19).

Table 4. Pearsons correlations between body mass, initial (5 &10 m), maximal velocity and momentum, Yo-Yo IRTL-1, 30-15IFT and Anaerobic Speed Reserve in Under 16 age category English Rugby Union Players

	Body Mass	**5mV**	**10mV**	**Vmax**	**5mMom**	**10mMom**	**MaxMom**	**Yo-Yo IRTL-1**	**30-15IFT**
5mV	-0.31 Moderate								
10mV	-0.34 Moderate	0.90 Extremely large							
Vmax	-0.25 Small	0.50 Large	0.65 Large						
5mMom	0.85 Very large	0.23 Small	0.14 Small	0.00 Trivial					
10mMom	0.91 Extremely large	0.08 Trivial	0.08 Trivial	0.00 Trivial	0.97 Extremely large				
MaxMom	0.92 Extremely large	-0.12 Small	-0.09 Trivial	0.14 Small	0.87 Very large	0.93 Extremely large			
Yo-Yo IRTL-1	-0.65 Large	0.44 Moderate	0.56 Large	0.41 Moderate	-0.35 Moderate	-0.38 Moderate	-0.43 Moderate		
30-15IFT	-0.59 Large	0.43 Moderate	0.52 Large	0.31 Moderate	-0.42 Moderate	-0.44 Moderate	-0.50 Large	0.88 Very large	
ASR	0.22 Small	0.12 Small	0.31 Moderate	0.81 Very large	0.28 Small	0.36 Moderate	0.52 Large	-0.13 Small	-0.31 Moderate

Data are presented as Pearsons correlation coefficients and qualitative descriptor based upon Hopkins' criteria (19). 5mV, Sprint velocity at 5 m; 10mV, Sprint velocity at 10 m; Vmax, maximal velocity; 5mMom, Sprint momentum at 5 m; 10mMom, Sprint momentum at 10 m; MaxMom, maximal momentum; Yo-Yo IRTL-1, Yo-Yo Intermittent Recovery Test Level 1; 30-15IFT, 30-15 Intermittent Fitness Test; ASR, Anaerobic Speed Reserve.

Table 5. Pearsons correlations between body mass, initial (5 &10 m), maximal velocity and momentum, Yo-Yo IRTL-1, 30-15IFT and Anaerobic Speed Reserve in Under 18 age category English Rugby Union Players

	Body Mass	**5mV**	**10mV**	**Vmax**	**5mMom**	**10mMom**	**MaxMom**	**Yo-Yo IRTL-1**	**30-15**
5mV	-0.30 Moderate								
10mV	-0.44 Moderate	0.80 Very large							
Vmax	-0.63 Large	0.45 Moderate	0.64 Large						
5mMom	0.93 Extremely large	0.06 Trivial	-0.16 Small	-0.50 Large					
10mMom	0.96 Extremely large	-0.08 Trivial	-0.17 Small	-0.50 Large	0.97 Extremely large				
MaxMom	0.90 Extremely large	-0.11 Small	-0.18 Small	-0.24 Small	0.90 Extremely large	0.93 Extremely large			
Yo-Yo IRTL-1	-0.74 Very large	0.37 Moderate	0.39 Moderage	0.60 Large	-0.64 Large	-0.69 Large	-0.61 Large		
30-15	-0.79 Very large	0.52 Large	0.43 Moderate	0.56 Large	-0.62 Large	-0.72 Very large	-0.67 Large	0.82 Very large	
ASR	-0.15 Small	0.08 Trivial	0.38 Moderate	0.82 Very large	-0.14 Small	-0.06 Trivial	0.24 Small	0.19 Small	-0.02 Trivial

Data are presented as Pearsons correlation coefficients and qualitative descriptor based upon Hopkins' criteria (19). 5mV, Sprint velocity at 5 m; 10mV, Sprint velocity at 10 m; Vmax, maximal velocity; 5mMom, Sprint momentum at 5 m; 10mMom, Sprint momentum at 10 m; MaxMom, maximal momentum; Yo-Yo IRTL-1, Yo-Yo Intermittent Recovery Test Level 1; 30-15IFT, 30-15 Intermittent Fitness Test; ASR, Anaerobic Speed Reserve.

Table 6 Pearsons correlations between body mass, initial (5 &10 m), maximal velocity and momentum, Yo-Yo IRTL-1, 30-15IFT and Anaerobic Speed Reserve in Under 21 age category English Rugby Union Players

Body Mass									
-0.25 Small	**5mV**								
-0.46 Moderate	0.92 Extremely large	**10mV**							
-0.87 Very large	0.33 Moderate	0.50 Large	**Vmax**						
0.90 Extremely large	0.20 Small	-0.05 Trivial	-0.74 Very large	**5mMom**					
0.92 Extremely large	0.12 Small	-0.08 Small	-0.76 Very large	0.99 Extremely large	**10mMom**				
0.99 Extremely large	-0.22 Small	-0.43 Moderate	-0.78 Very large	0.89 Very large	0.91 Extremely large	**MaxMom**			
-0.72 Very large	0.10 Small	0.25 Small	0.70 Large	-0.71 Very large	-0.73 Very large	-0.74 Very large	**Yo-Yo IRTL-1**		
-0.71 Very large	0.12 Small	0.27 Small	0.58 Large	-0.68 Large	-0.68 Large	-0.70 Very large	0.96 Extremely large	**30-15**	
-0.26 Small	0.42 Moderate	0.42 Moderate	0.59 Large	-0.10 Small	-0.13 Small	-0.15 Small	-0.26 Small	-0.31 Moderate	**ASR**

Data are presented as Pearsons correlation coefficients and qualitative descriptor based upon Hopkins' criteria (19). 5mV, Sprint velocity at 5 m; 10mV, Sprint velocity at 10 m; Vmax, maximal velocity; 5mMom, Sprint momentum at 5 m; 10mMom, Sprint momentum at 10 m; MaxMom, maximal momentum; Yo-Yo IRTL-1, Yo-Yo Intermittent Recovery Test Level 1; 30-15IFT, 30-15 Intermittent Fitness Test; ASR, Anaerobic Speed Reserve.