Anthropometric and Physical Characteristics of English Academy Rugby League Players

Running Head: Characteristics of Academy Rugby League Players

Kevin Till, Emma Tester, Ben Jones, Stacey Emmonds, Jack Fahey & Carlton Cooke

Research Institute for Sport, Physical Activity and Leisure, Leeds Metropolitan University,

Leeds, West Yorkshire, United Kingdom

Corresponding Author:

Dr. Kevin Till

Room 1111, Fairfax Hall

Research Institute for Sport, Physical Activity and Leisure

Headingley Campus, Leeds Metropolitan University

W.Yorkshire, LS6 3QS

Phone: (044-11) 01132-832600 Ext: 25182

Email: k.till@leedsmet.ac.uk

ABSTRACT

The purpose of the current study was to evaluate the anthropometric and physical characteristics of English academy rugby league players by annual-age category (Under 16s – Under 20s) and between backs and forwards. Data was collected on 133 academy players over a 6 year period (resulting in a total of 257 assessments). Player assessments comprised of anthropometric (height, body mass, sum of 4 skinfolds) and physical (vertical jump, 10m and 20m sprint, estimated $\dot{V}O_{2max}$ via the yo-yo intermittent recovery test level 1, absolute 1-RM and relative squat, bench press and prone row) measures. Univariate analysis of variance demonstrated significant ($p<0.05$) increases in height, body mass, vertical jump, absolute and relative strength measures across the five annual-age categories (e.g., Body Mass – Under 16s = 75.2 ± 11.1, Under 20s = 88.9 ± 8.5kg; Vertical Jump – Under 16s = 45.7 ± 5.2, Under 20s = 52.8 ± 5.4cm; 1-RM Bench Press – Under 16s = 73.9 ± 13.2, Under 20s = 114.3 ± 15.3kg). Independent t-tests identified significant ($p<0.05$) differences between backs and forwards for anthropometric (e.g., Under 16s body mass – Backs = 68.4 ± 8.6, Forwards = 80.9 ± 9.7kg) and physical (e.g., Under 19s 20m sprint – Backs = 3.04 ± 0.08, Forwards = 3.14 ± 0.12s; Under 18s relative squat – Backs = 1.65 ± 0.18, Forwards = 1.51 ± 0.17kg/kg) characteristics that were dependant on the age category and measure assessed. Findings highlight that anthropometric and physical characteristics develop across annual-age categories and between backs and forwards in academy rugby league players. These findings provide comparative data for such populations and support the need to monitor player development in junior rugby league players.

Key words: anthropometry, strength, fitness, playing position, age category, junior

INTRODUCTION

Rugby league is an intermittent, collision team sport played at amateur and professional levels across junior and senior age categories worldwide (13). Professional teams and game popularity is most established in Great Britain, France, Australia and New Zealand (7, 28) with the European Super League and Australasian National Rugby League the two major professional leagues in the world. Rugby league consists of frequent bouts of high intensity activity (e.g., sprinting, tackling, ball carrying) separated by bouts of low intensity activity (e.g., walking, jogging; 9, 13), requiring players to have highly developed aerobic and anaerobic capacities in order to compete at an elite level, due to the large distances covered and the high intensity activities undertaken during a game.

Research presenting the anthropometric and physical characteristics of junior rugby league players in Australia is well documented (2, 8, 10, 11, 12, 14, 16, 17, 18). This research has demonstrated that anthropometric and physical characteristics develop across annual-age categories, increase with playing level and differ between playing positions. For anthropometric characteristics, height and body mass increased across Under 14, 16 and 18 age categories (14); body mass was greater in elite compared to sub-elite junior players (17); and height and body mass were greater in forwards compared to backs positions (10). For sum of skinfolds, no differences have been identified across age categories (14) with forwards again having a higher sum of skinfolds than backs (10, 17).

For physical characteristics, vertical jump, sprint speed and maximal aerobic power have all been identified to increase from Under 13s to 19s age categories (8, 14, 16) with elite players outperforming sub-elite junior players (16, 17). However, no significant differences have been identified for vertical jump between playing position (8, 10) while backs have demonstrated to be quicker than forwards (10, 16). For maximal aerobic power, findings in relation to playing position are contradictory with some studies (8, 10, 16) finding backs outperformed forwards, while others found no significant differences between playing positions (17). Although data presenting anthropometric and physical characteristics within junior rugby league players is available, data examining strength characteristics is limited (2).

In the UK, comprehensive anthropometric and physical data is available for regional and national representative players aged between 13 and 15 years (29, 30, 31, 32). However, data examining the characteristics of players from an English rugby league academy (i.e., aged between 16 and 20 years) is limited, with only recent data available that examines the strength, power and speed characteristics of an Under 20s Super League academy squad (24). The authors identified that backs outperformed forwards for 10 m, 20 m and 40 m sprint with no significant differences found for height, body mass, vertical jump, absolute and relative bench press and squat strength (24). Although these findings provided comparative data for this playing population, establishing further comparative data for junior rugby league players in the UK across the Under 16 to Under 20 annual-age categories is of vast importance for monitoring athlete development alongside player recruitment and identification.

Therefore, the purpose of the current study was to present the anthropometric and physical characteristics of English academy rugby league players from Under 16 to Under 20 age categories. The secondary purpose was then to evaluate the development of anthropometric and physical characteristics across annual-age categories and between playing positions (i.e., backs and forwards). It was hypothesized that anthropometric and physical characteristics would develop across annual-age categories and would differ between backs and forwards.

METHODS

Experimental Approach to the Problem

Junior rugby league players from a professional English Super League club's academy were assessed on a range of performance tests over a 6 year period. Players were assessed on anthropometric (height, body mass and sum of four skinfolds) and physical (10 m and 20 m sprint, vertical jump, yo-yo recovery test, 1-RM squat, bench press and row) characteristics across 5 annual-age categories (Under 16s, 17s, 18s, 19s and 20s). This approach allowed comparisons between academy rugby league players across annual-age categories and between positional backs and forwards.

Subjects

A total of 133 junior rugby league players were investigated between 2007 and 2012. This resulted in a total of 257 player assessments (Under 16s, n = 68; Under 17s, n = 51; Under 18s, n = 61; Under 19s, n = 50; Under 20s, n = 27) during that time. All players trained at the club, in which, the Under 16s age category performed one gym based and one skill based field session per week, whilst also training and competing with their local club. Under 17s to 20s players only trained at the professional club and this typically included three gym and two field based sessions in the pre-season period (November – March) and two gym and three field based sessions alongside one game during the season (March – September). All experimental procedures were approved by the Leeds Metropolitan University Ethics Committee.

Procedures

All testing was completed across two testing sessions in November each year at the beginning of a pre-season period. The first testing session incorporated field based assessments involving a 10 m and 20 m sprint and the yo-yo recovery test level 1. The second testing session incorprated gym based testing including anthropometric (height, body mass, sum of 4 skinfolds), vertical jump and 1-RM strength (squat, bench press and prone row) measures. A standardised warm up including jogging, dynamic movements and stretches was used prior to testing followed by full instruction and demonstrations of the assessments. All testing was undertaken by the lead researcher throughout the 6 year period.

Anthropometry: Height was measured to the nearest 0.1cm using a Seca Alpha stand. Body mass, wearing only shorts, was measured to the nearest 0.1kg using calibrated Seca alpha (model 770) scales. Sum of four skinfolds was determined by measuring four skinfold sites (biceps, triceps, subscapular, suprailiac) using calibrated Harpenden skinfold callipers (British Indicators, UK) in accordance with Hawes and Martin (22).

Lower body power: A countermovement jump with hands positioned on hips was used to assess lower body power via a just jump mat (Probotics, USA). Jump height was measured to the nearest 0.1cm from the highest of three attempts (21) with 60 s rest allowed between each assessment. Intraclass correlation coefficient (ICC) and coefficient of variation (CV) for the vertical jump was r = 0.92 and 2.6%.

Speed: Sprint speed was assessed over 10 m and 20 m using timing gates (Brower Timing Systems, IR Emit, USA). Players started 0.5 m behind the initial timing gate and were instructed to set off in their own time and run maximally past the 20 m timing gate. Times were recorded to the nearest 0.01 s with the quickest of the three times used for the sprint score. ICC and CV's for 10 m and 20 m sprint speed was r = 0.85, CV = 4.5% and r = 0.91, CV = 3.0% respectively.

Estimated maximum oxygen uptake ($\dot{V}O_{2max}$): Estimated $\dot{V}O_{2max}$ was predicted via the yo-yo intermittent recovery test level 1 (25), which has recently been used in rugby league (21).

Players were required to run 20m shuttles, followed by a 10 second rest interval, keeping to a series of beeps. Running speed increased progressively until the players reached volitional exhaustion. Estimated $\dot{V}O_{2max}$ was predicted via the equation *distance run (in metres)* × *0.0084 + 36.4* (6). Previous research (25) has shown an ICC and CV for the yo-yo intermittent recovery test level 1 of r = 0.98 and CV = 4.6%.

Strength: One repetition (1-RM) squat, bench press and prone row were used as measures of lower body, upper body pushing and upper body pulling strength respectively. All players were accustomed to these exercises as they were regularly used as part of their training programme and any player who did not demonstrate competent technique was not assessed on these measures. Participants performed a warm up protocol of 8, 5 and 3 repetitions of individually selected loads before three attempts of their 1-RM with 3 minutes rest between attempts prescribed. The 1-RM squat and bench press protocol was completed using a 2.13m (7ft) Olympic bar and free weights. All players had to squat until the top of the thigh was parallel with the ground, which was visually determined by the lead researcher (5). Players then had to return to a standing position with adequate technique to record a 1-RM score. For the bench press, athletes lowered the barbell to touch the chest and then pushed the barbell until elbows were locked out. For the prone row, also known as a bench pull, a 1.52m (5ft) bar was used with players lay face down on a bench. The bench height was determined so player's arms were locked out at the bottom position and then had to pull the barbell towards the bench. 1-RM lifts were only included if both sides of the barbell touched the bench. Following all strength assessments, player's 1-RM scores were divided by body mass to provide a strength score relative to body mass. A bench press / prone row ratio (%) was also calculated to examine pushing and pulling strength.

Data Analysis

Data are presented as mean ± standard deviations by annual-age category and backs and forwards by age category. Preliminary analyses were conducted to check for normality with Kolmogorov-Smirnov tests performed on the data set to check data distribution with $p<0.05$ indicating normality. Univariate analysis of variance (ANOVA) were used to examine the differences between annual-age categories for all players, backs and forwards with a Tukey post-hoc test used. Independent samples t-tests were used to analyse differences between backs and forwards at each respective age category. Partial eta squared effect sizes (η^2) were calculated with all analysis. SPSS version 19.0 was used to conduct analysis with all statistical significance set at $p<0.05$.

RESULTS

Table 1 shows the anthropometric and physical characteristics of academy rugby league players by annual-age category (Under 16s – 20s). Findings identified annual-age category had a significant effect on height ($p<0.001$, η^2=0.12), body mass ($p<0.001$, η^2=0.21), vertical jump ($p<0.001$, η^2=0.19), estimated $\dot{V}O_{2max}$ ($p=0.022$, η^2=0.05), 1-RM squat ($p<0.001$, η^2=0.35), relative squat ($p<0.001$, η^2=0.14), 1-RM bench press ($p<0.001$, η^2=0.46), relative bench press ($p<0.001$, η^2=0.31), 1-RM prone row ($p<0.001$, η^2=0.45), relative prone row ($p<0.001$, η^2=0.22) and bench press / prone row ratio ($p<0.001$, η^2=0.0.12). Overall, findings demonstrated as age increased so did anthropometric, vertical jump, estimated $\dot{V}O_{2max}$ and strength characteristics. For sum of four skinfolds and 10 m and 20 m sprint no significant differences were identified across the age categories.

Insert Table 1 here

Table 2 shows the anthropometric and physical characteristics of academy rugby league players by annual-age category for backs and forwards. For backs, annual-age category had a significant effect on height ($p=0.004$, $\eta^2=0.16$), body mass ($p<0.001$, $\eta^2=0.36$), vertical jump ($p=0.001$, $\eta^2=0.16$), 1-RM squat ($p<0.001$, $\eta^2=0.33$), relative squat ($p=0.001$, $\eta^2=0.19$), 1-RM bench press ($p<0.001$, $\eta^2=0.50$), relative bench press ($p<0.001$, $\eta^2=0.41$), 1-RM prone row ($p<0.001$, $\eta^2=0.42$) and relative prone row ($p<0.001$, $\eta^2=0.26$). For forwards, annual-age category had a significant effect on height ($p=0.003$, $\eta^2=0.13$), body mass ($p<0.001$, $\eta^2=0.24$), vertical jump ($p<0.001$, $\eta^2=0.23$), 1-RM squat ($p<0.001$, $\eta^2=0.40$), relative squat ($p=0.002$, $\eta^2=0.14$), 1-RM bench press ($p<0.001$, $\eta^2=0.45$), relative bench press ($p<0.001$, $\eta^2=0.25$), 1-RM prone row ($p<0.001$, $\eta^2=0.52$) and relative prone row ($p<0.001$, $\eta^2=0.21$). Findings demonstrated that the Under 16s were the lowest performing age category for the characteristics identified as significant.

Insert Table 2 here

Table 2 also identifies the significant differences between backs and forwards at each annual-age category. At Under 16s, significant differences were apparent for height ($p=0.008$, $\eta^2=0.10$), body mass ($p<0.001$, $\eta^2=0.32$), sum of 4 skinfolds ($p<0.001$, $\eta^2=0.23$), vertical jump ($p=0.001$, $\eta^2=0.17$), 10 m ($p<0.001$, $\eta^2=0.26$) and 20 m sprint ($p<0.001$, $\eta^2=0.23$) between backs and forwards. At Under 17s significant differences between backs and forwards were identified for height ($p<0.001$, $\eta^2=0.36$), body mass ($p<0.001$, $\eta^2=0.27$), sum of 4 skinfolds ($p=0.012$, $\eta^2=0.13$), vertical jump ($p=0.023$, $\eta^2=0.10$), 10 m ($p=0.025$, $\eta^2=0.15$), 20 m sprint ($p=0.011$, $\eta^2=0.19$) and 1-RM prone row ($p=0.023$, $\eta^2=0.11$). At Under 18s significant differences were identified for height ($p=0.001$, $\eta^2=0.21$), body mass ($p<0.001$, $\eta^2=0.39$), sum of 4 skinfolds ($p<0.001$, $\eta^2=0.20$), vertical jump ($p=0.023$, $\eta^2=0.09$), relative squat ($p=0.008$, $\eta^2=0.13$), 1-RM bench press (p=0.030, η^2=0.09) and 1-RM prone row (p=0.006, η^2=0.14) between backs and forwards. At Under 19s significant differences between backs and forwards were identified for body mass (p<0.001, η^2=0.37), sum of 4 skinfolds (p<0.001, η^2=0.22), 20 m sprint (p=0.026, η^2=0.18), relative bench press (p=0.027, η^2=0.11) and 1-RM prone row (p=0.023, η^2=0.12). At Under 20s significant differences were identified for body mass (p=0.016, η^2=0.21), sum of 4 skinfolds (p=0.025, η^2=0.19), 10 m (p=0.048, η^2=0.24) and 20 m (p=0.002, η^2=0.48) sprint between backs and forwards. Forwards had greater height, body mass, sum of four skinfolds and 1-RM strength while backs demonstrated greater vertical jump, speed and relative strength.

DISCUSSION

The purpose of the current study was to evaluate the anthropometric and physical characteristics of junior rugby league players from an English Super League academy (Under 16s to Under 20s) across annual-age categories and between backs and forwards. As hypothesized, anthropometric (height and body mass) and physical (vertical jump and strength) characteristics developed across annual-age categories for all players and for backs and forwards respectively. No differences were identified between sum of four skinfolds, 10m and 20m sprint and estimated $\dot{V}O_{2max}$ between the annual-age categories. When backs and forwards were compared differences were evident for anthropometric and physical characteristics but findings were not consistent for all assessments and at all annual-age categories.

Height and body mass were shown to significantly develop across annual-age categories for all players, backs and forwards with no differences identified for sum of four skinfolds across the age categories. This therefore supports and contrasts the hypothesis that all anthropometric characteristics develop across annual-age categories. For height and body mass, post-hoc analysis identified significant differences between the younger (i.e., Under 16s - Height = 175.7 ± 7.1cm, Body Mass = 75.2 ± 11.1kg) and older (i.e., Under 19s - Height = 181.4 ± 5.4cm, Body Mass = 88.8 ± 9.9kg) age categories. This is consistent with previous research in rugby league (8, 14, 16) and occurs due to the normal adaptations related to growth, maturation and development in that height and body mass will continue to develop into late adolescence (26). Little change in height would be expected post 18 years as most players will have approached adult height with body mass expected to continue to increase into senior levels with the inclusion of resistance training programmes and advanced nutrition. For sum of four skinfolds, no significant differences were apparent across the age categories, suggesting that practitioners should not expect to see differences between age categories for sum of four skinfolds. However, due to the large standard deviations and ranges (i.e., Under 18s, 18.0 - 73.3mm), there is large inter-individual variation within sum of four skinfold scores within an academy squad. Therefore, practitioners could assign individual targets based on the presented means of the current data set, with suggested targets of below 30mm for backs and 40mm for forwards appropriate targets. Implementing additional training and nutritional interventions could enhance these measurements with lower skinfold scores correlated with improved physical performance (30). However, optimum skinfold scores are not currently known and coaches should be aware of individual variability when assessing skinfold measures.

When compared with previous UK data of an academy squad, anthropometric characteristics seem consistent (e.g., Under 20s Backs - Height = 176.8 ± 6.1cm, Body Mass 82.8 ± 6.3 kg; Forwards - Height = 180.1 ± 7.7cm, Body Mass 90.1 ± 11.7 kg, 24). However, anthropometric characteristics in Australian samples appear lower (e.g., Under 16s height = 172.7 ± 4.9 cm, Body Mass = 65.2±9.6 kg; 14) with these differences possibly due to the timing of testing within annual-age categories, the playing level of the groups, differences in player identification and recruitment policies and maturational differences between players in respective squads. Therefore, it is important to consider these factors in comparisons of anthropometric data between playing squads.

For physical characteristics, the findings support and negate the hypothesis that characteristics would increase across the annual-age categories. Vertical jump performance significantly increased across the annual-age categories for all players, backs and forwards. (i.e., Under 16s = 45.7 ± 5.2 cm; Under 20s = 52.8 ± 5.4 cm). These findings are consistent with previous Australian studies (8, 14) and data at Under 13-15s levels in UK based players (29) emphasising that lower body power improves with age due to the adaptations related to growth and maturation (26) alongside the increased amount of strength and power training that players would undertake with advancing age within an academy set up. No significant differences were identified for 10 m and 20 m sprint and estimated $\dot{V}O_{2max}$ relative to body mass, measured via the yo-yo intermittent recovery test level 1, across the five age categories. Similar findings were shown in Australian research (8, 14, 16, 18) between Under 16 and Under 19 age categories. However, previous research (29, 30, 31) in UK players between Under 13s and 15s has demonstrated an improvement in speed and estimated $\dot{V}O_{2max}$ with age. The current findings demonstrate that speed and estimated $\dot{V}O_{2max}$ do not differentiate between age categories with the timing of testing (i.e., at the beginning of pre-season) a possible explanation for this finding with testing undertaken following an off-season rest period. Although players will have undertaken training during the season, the results demonstrate that on average no significant improvements occur with age on an annual basis suggesting growth processes post 16 years may not have impacted speed and aerobic capacity development as previously demonstrated at adolescent ages

(Under 13s-15s; 29, 30, 31). Further research examining the effects of pre-season and in-season training on performance changes are required along with longitudinal evaluations of the development of physical capacities.

Given that the intensity of rugby league match play will likely increase with advancing age (although this is not evidenced in the UK, this has been evidenced in Australia; 15) it would be expected that speed and maximal aerobic capacity would develop with age. It may be more likely factors related to a combination of anthropometric and physical characteristics (e.g., momentum, absolute $\dot{V}O_{2max}$) may increase to meet the increasing match demands but research evaluating these data are limited (5). Further, these data represent the mean and standard deviation of an English academy squad, which does not identify those players that are successful on progression to senior levels, which may be a further avenue for longitudinal evaluations.

In comparison with previous UK research (24) vertical jump data is consistent (e.g., Under 20s Backs = 50.6 ± 5.0cm, Forwards = 50.6 ± 7.1cm), however sprint performance seems higher in the current sample (e.g., 20 m sprint - Under 20s Backs = 3.26 ± 0.07s, Forwards = 3.39 ± 0.17s; 24). Similarly, results in the current sample seem higher than those presented in Australian populations for vertical jump (e.g., Under 16s Backs = 41.2 ± 3.5cm, Forwards = 38.0 ± 3.6cm, 8), 20m sprint (e.g., Under 18s = 3.22 ± 0.09s; 14) and estimated $\dot{V}O_{2max}$ (e.g., Under 18s = 43.1 ± 1.1 $ml.kg^{-1}.min^{-1}$; 16). However, caution needs to be taken when comparing these scores due to the level of player assessed, the methods used for data collection and the timing of testing within a pre-season programme.

Although data presenting anthropometric and physical characteristics within junior rugby league players is consistently available, data examining strength characteristics is limited (2, 24). Current results are the first to provide comparative strength data across an academy squad from

Under 16s to Under 20s with findings supporting the hypothesis that absolute and relative strength developed across annual-age categories. For absolute 1-RM strength for the squat, bench press and prone row, data demonstrated increases across all age categories except between the Under 19s and 20s age categories. Although changes in relative strength were still apparent with age, these findings were not as obvious as absolute strength due to the increases in body mass, which would be aligned with increases in strength. These findings differ from the speed and estimated $\dot{V}O_{2max}$ results in that strength increased on an annual basis, with strength gains more stable following a training intervention. Annual increases in strength may have been evident due to the volume of strength training the players undertook (i.e., Under 16s - 1 session per week / Under 17s-20s - 2-3 sessions per week) alongside increasing growth demonstrated by the increase in anthropometric characteristics.

In comparison with previous UK data (24) our findings revealed higher values for absolute strength (e.g., Bench Press - Backs = 101.67 ± 9.13 kg, Forwards = 110.00 ± 15.80 kg; Squat - Backs = 132.71 ± 9.38 kg, Forwards = 140.21 ± 26.21 kg) but similar results for relative strength. These differences may again be due to differences in testing procedures or that Kirkpatrick and Comfort (24) did not split their sample into specific age categories and classified all players as Under 20s. However, previous research has demonstrated the importance of developing lower body strength to enhance acceleration (27, 34) with previous research in rugby league recommending conditioning coaches develop training programmes to enhance max squat strength alongside sprint and jump performance (24). Data examining pulling strength within rugby league players is limited (3) with studies consistently presenting squat and bench press data (1, 4, 5, 24). The current findings demonstrate a bench press to prone row ratio of between 104.1 ± 14.4% (Under 16s) and 116.6 ± 10.6% (Under 19s), which is considerably higher than those reported in professional players of 97.7 ± 9.0% (3). These findings may be apparent due to the difference in the pulling strength test used (i.e., prone row vs pull up), the training programmes of the players or previous training experience on selection into the academy. However, it is recommended pushing to pulling ratio should be approximately 100% (3), suggesting academy players may have an imbalance towards pushing strength and therefore training programmes should look to consider and address this accordingly with further research required understanding the implications of such imbalances.

For evaluations between backs and forwards, findings support hypothesis with a range of anthropometric and physical differences identified at each of the annual-age categories. Height (at Under 16s-18s), body mass and sum of four skinfolds were consistently higher in the forwards than the backs. This finding is consistent with previous research (10, 16, 24, 29), even though some studies have not presented significant differences. This finding emphasizes the importance of greater physical size in forwards positions due to the greater number of physical collisions (i.e., ball carries and tackles) they are involved in compared to backs (19, 20). For physical characteristics, vertical jump and 10m and 20m sprint speed demonstrated some (e.g., Under 16s vertical jump, Under 19s 20m sprint) significant differences with backs outperforming forwards on these measures. This is again consistent with some previous research (10, 16, 29) and contradicts others (24) but on the whole demonstrates backs are generally quicker and more powerful than forwards, which may be required for their game demands. Previous research (29) has demonstrated a negative relationship between sum of four skinfolds and physical qualities (e.g., vertical jump) due to a reduction in power to body mass ratio (13). Future research may be worthwhile to compare variables that combine anthropometry and physical measures (e.g., momentum, peak power), which may be more important for rugby league performance (5).

Interestingly, no significant differences were found between backs and forwards for estimated $\dot{V}O_{2max}$. This is similar to some research findings (17) but differs to others (10, 16, 29). Previous research has examined positional data by positional groupings (i.e., props, backrow, pivots, outside-backs) and this may be a possible reason why no significant differences were identified. For strength characteristics, significant differences were only identified for certain measures at specific age categories (e.g., Under 17s 1-RM prone row, Under 19s relative bench press).

In conclusion, the current study presents comparative data for anthropometric and physical characteristics for English academy rugby league players from Under 16s to Under 20s age categories. The findings demonstrate that height, body mass, vertical jump and strength measures increased with age throughout an academy, while sum of four skinfolds, speed and estimated $\dot{V}O_{2max}$ did not seem to follow the same trend. This suggests that sum of four skinfolds, speed and estimated $\dot{V}O_{2max}$ do not differ between age categories possibly suggesting these characteristics do not increase on an annual basis, possibly due to the timing of the testing protocol (i.e., start of pre-season) within an annual periodized programme. On the other hand, body mass, vertical jump and strength measures increase with age and training adaptations on an annual basis. That said, high standard deviations and ranges demonstrate that there is large inter individual variation in anthropometric and physical characteristics between individuals within chronological annual-age groups, which may be due to factors such as maturation, training age and response to training. These current findings could be used as a basis for comparing players to establish identification processes and response to training. However, the current findings are limited to cross-sectional data with further studies examining the longitudinal change in performance within and between seasons necessary in the future.

PRACTICAL APPLICATIONS

Current findings provide comparative data for English academy rugby league players by annual-age category (Under 16s to Under 20s) and between backs and forwards. It is recommended that such data should be used by strength and conditioning coaches and player development staff for player identification, assessing individual player's strengths and weaknesses and monitoring player development. Coaches should be aware that height, body mass, vertical jump and strength measures improve between seasons (and therefore age categories) throughout an academy while sum of four skinfolds, speed and estimated $\dot{V}O_{2max}$ do not improve between seasons suggesting within season improvements may return to similar levels at the start of a pre-season training programme. Further, understanding that forwards are bigger with greater absolute (1-RM) strength than backs who possess greater speed, lower body power and relative strength may contribute to coaches identifying the suitability of players to certain playing positions. However, the large degree of inter player variability observed highlights the importance of tracking the development of fitness and strength characteristics on an individual and longitudinal basis (33). Also, coaches should understand the importance of standardized testing procedures and timing if data is to be appropriately compared.

REFERENCES

1. Baker, DG. Comparison of upper-body strength and power between professional and college-aged rugby league players. *J Strength Cond Res* 15: 30–35, 2001.
2. Baker, DG. Differences in strength and power among junior-high, senior-high, college-aged, and elite professional rugby league players. *J Strength Cond Res* 16: 581-585, 2002.
3. Baker, DG, and Newton RU. An analysis of the ratio and relationship between upper body pressing and pulling strength. *J Strength Cond Res* 18: 594-598. 2004.
4. Baker, DG, and Newton RU. Adaptations in upper-body maximal strength and power output resulting from long-term resistance training in experienced strength-power athletes. *J Strength Cond Res* 20: 541-546. 2006.
5. Baker, DG, and Newton, RU. Comparison of lower body strength, power, acceleration, speed, agility, and sprint momentum to describe and compare playing rank among professional rugby league players. *J Strength Cond Res* 22: 153-158, 2008.
6. Bangsbo, J, Iaia, FM, and Krustrup, P. The yo-yo intermittent recovery test: A useful tool for evaluation of physical performance in intermittent sports. *Sports Med* 38: 37-51, 2008.
7. Brewer, J, and Davis, J. Applied physiology of rugby league. *Sports Med* 20: 129–135, 1995.
8. Gabbett, TJ. Physiological characteristics of junior and senior rugby league players. *Br J Sports Med* 36: 334–339, 2002
9. Gabbett, TJ. Science of rugby league football: a review. *J Sports Sci* 23: 961-976, 2005.

10. Gabbett, TJ. A comparison of physiological and anthropometric characteristics among playing positions in junior rugby league players. *Br J Sports Med* 39: 675-680, 2005.
11. Gabbett, TJ. Physiological and anthropometric characteristics of junior rugby league players over a competitive season. *J Strength Cond Res* 19: 764-771, 2005.
12. Gabbett, TJ. Performance changes following a field conditioning program in junior and senior rugby league players. *J Strength Cond Res* 20: 215-221, 2006.
13. Gabbett, TJ. Applied Physiology of Rugby League. *Sports Med* 38: 119-138, 2008.
14. Gabbett, TJ. Physiological and anthropometric characteristics of starter and non-starters in junior rugby league players, aged 13-17 years. *J Sports Med Phys Fit* 49: 233-239, 2009.
15. Gabbett, TJ. Activity cycles of National Rugby League and National Youth Competition matches. *J Strength Cond Res* 26: 1517-1523, 2012.
16. Gabbett, TJ, and Herzig, PJ. Physiological characteristics of junior elite and sub-elite rugby league players. *Strength Cond Coach* 12: 19–24, 2004.
17. Gabbett, TJ, Kelly, J, Ralph, S, and Driscoll, D. Physiological and anthropometric characteristics of junior elite and sub-elite rugby league players, with special reference to starters and non starters. *J Sci Med Sport* 12: 1126-1133, 2007.
18. Gabbett, TJ, Johns, J, and Riemann, M. Performance changes following training in junior rugby league players. *J Strength Cond Res* 22: 910-917, 2008.
19. Gabbett, TJ, Jenkins, DJ, and Abernethy, B. Physical collisions and injury in professional rugby league match-play. *J Sci Med Sport* 14: 210-215, 2011
20. Gabbett, TJ, Jenkins, DJ, and Abernethy, B. Physical demands of professional rugby league training and competition using microtechnology. *J Sci Med Sport* 15: 80-86, 2012

21. Gabbett, TJ, and Seibold, A. Relationship between tests of physical qualities, team selection, and physical match performance in semi-professional rugby league players. *J Strength Cond Res* 25, 2013 [Epub ahead of print]

22. Hawes, MR and Martin, AD. Human body composition. In: Kinanthropometry and Exercise Physiology Laboratory Manual: Tests, Procedures and Data. Anthropometry. (2nd ed., Vol. 1). Eston R. and Reilly T, eds. London: Routledge, 7–43, 2001. .

23. Hunter, JP, and Marshall, RN. Effects of power and flexibility training on vertical jump technique. *Med Sci Sports Exerc* 34: 478-486, 2002.

24. Kirkpatrick, J, and Comfort, P. Strength, power and speed qualities in English junior elite rugby league players. *J Strength Cond Res* 2012 [Epub ahead of print]

25. Krustrup, P, Mohr, M, Amstrup, T, Rysgaard, T, Johansen, J, Steensberg, A, Redersen, PK, and Bangsbo, J. The yo-yo intermittent recovery test: physiological response, reliability, and validity. *Med Sci Sports Exerc*. 35: 697-705, 2003.

26. Malina, RM, Bouchard, C, and Bar-Or, O. Growth, Maturation, and Physical Activity (2nd ed.). Champaign, IL: Human Kinetics, 2004.

27. McBride, JM, Blow, D, Kirby, TJ, Haines, TL, Dayne, AM, and Triplett, NT. Relationship between maximal squat strength and five, ten, and forty yard sprint times. *J Strength Cond Res* 23: 1633–1636, 2009.

28. Meir, R, Newton, R, Curtis, E, Fardell, M, and Butler, B. Physical fitness qualities of professional rugby league football players: Determination of positional differences. *J Strength Cond Res* 15: 450–458, 2001.

29. Till, K, Cobley, S, O'Hara, J, Chapman, C, and Cooke, C. Anthropometric, physiological and selection characteristics in high performance UK junior rugby league players. *Talent Development Excellence* 2: 193-207, 2010.

30. Till, K, Cobley, S, O'Hara, J, Brightmore, A, Chapman, C, and Cooke, C. Using anthropometric and performance characteristics to predict selection in junior UK rugby league players. *J Sci Med Sport* 14: 264-269, 2011.

31. Till, K, Cobley, S, O'Hara, J, Chapman, C, and Cooke, C. Considering maturation and relative age in the longitudinal evaluation of junior rugby league players. *Scand J Sci Med Sport.* 2013 [Epub ahead of print]

32. Till, K, Cobley, S, O'Hara, J, Chapman, C, and Cooke, C. A Longitudinal evaluation of anthropometric and fitness characteristics in junior rugby league players. *J Sci Med Sport.* 2012 [Epub ahead of print]

33. Till, K, Cobley, S, O'Hara, J, Chapman, C, and Cooke, C. An individualized longitudinal approach to monitoring the dynamics of growth and fitness development in adolescent athletes. *J Strength Cond Res* 27: 1313-1321, 2013.

34. Wisloff, U, Castagna, C, Helgerud, J, Jones, R, and Hoff, J. Strong correlation of maximal squat strength with sprint performance and vertical jump height in elite soccer players. *Br J Sport Med* 38: 285–288, 2004.

Table 1. Anthropometric and Physical Characteristics of Academy Rugby League Players by Age Category

	N	Under 16s (1) Mean ± SD (Min – Max)	N	Under 17s (2) Mean ± SD (Min – Max)	N	Under 18s (3) Mean ± SD (Min – Max)	N	Under 19s (4) Mean ± SD (Min – Max)	N	Under 20s (5) Mean ± SD (Min – Max)	Post-hoc
Height (cm)	68	175.7 ± 7.1 (150.2 - 190.6)	51	177.0 ± 6.0 (167.2 - 190.6)	61	179.5 ± 5.8 (167.5 - 193.5)	50	181.4 ± 5.4 (168.9 - 194.2)	27	180.1 ± 5.3 (170.4 - 188.9)	1 < 4, 5 2 < 4
Body Mass (kg)	68	75.2 ± 11.1 (42.7 - 98.8)	51	81.1 ± 9.4 (63.8 - 104.4)	61	85.3 ± 10.0 (61.4 – 111.5)	50	88.8 ± 9.9 (64.0 – 110.6)	27	88.9 ± 8.5 (75.1 – 112.7)	1 < 2 < 4, 5 1 < 3
∑ 4 Skinfolds (mm)	68	37.2 ± 12.7 (20.7 – 75.0)	51	36.5 ± 12.8 (20.7 – 75.6)	61	38.1 ± 12.1 (18.0 – 73.3)	50	37.9 ± 13.2 (19.4 – 75.5)	27	35.8 ± 9.1 (24.0 – 57.0)	
Vertical Jump (cm)	67	45.7 ± 5.2 (33.7 – 56.7)	50	49.1 ± 5.8 (36.3 – 62.0)	56	50.6 ± 5.7 (37.6 – 65.5)	45	52.5 ± 5.5 (42.5 – 65.5)	25	52.8 ± 5.4 (45.0 – 63.5)	1 < 2 < 4, 5 1 < 3
10m Sprint (s)	67	1.82 ± 0.07 (1.66 – 1.99)	45	1.81 ± 0.06 (1.69 – 1.95)	49	1.80 ± 0.06 (1.65 – 1.94)	39	1.82 ± 0.07 (1.71 – 2.01)	22	1.79 ± 0.06 (1.67 – 1.88)	
20m Sprint (s)	67	3.13 ± 0.11 (2.85 – 3.36)	45	3.12 ± 0.10 (2.96 – 3.34)	49	3.09 ± 0.10 (2.83 – 3.35)	39	3.11 ± 0.12 (2.94 – 3.42)	22	3.07 ± 0.12 (2.83 – 3,42)	
Estimated VO2max ($ml.kg^{-1}.min^{-1}$)	64	47.3 ± 3.4 (42.0 – 57.1)	46	48.7 ± 2.8 (43.9 – 54.4)	55	48.9 ± 2.9 (43.1 – 56.6)	44	48.5 ± 2.9 (43.1 – 53.9)	23	48.9 ± 2.8 (43.1 – 54.5)	
1-RM Squat (kg)	30	100.4 ± 21.9 (60 - 147.5)	48	122.2 ± 18.7 (70 - 160)	55	134.0 ± 15.5 (105 - 180)	45	138.4 ± 19.6 (92.5 - 180)	26	144.6 ± 22.1 (95 - 190)	1 < 2 < 4, 5 1 < 3
Relative Squat (kg/kg)	30	1.33 ± 0.25 (0.60 - 1.82)	48	1.50 ± 0.22 (0.88 - 2.00)	55	1.57 ± 0.21 (1.27 - 2.10)	45	1.58 ± 0.21 (1.12 - 2.03)	26	1.62 ± 0.25 (1.12 - 2.04)	1 < 2, 3, 4, 5
1-RM Bench Press (kg)	31	73.9 ± 13.2 (45 - 100)	48	93.3 ± 13.4 (65 - 120)	55	103.7 ± 15.3 (62.5 - 142.5)	48	113.3 ± 16.4 (70 - 147.5)	26	114.3 ± 15.3 (82.5 - 145)	1 < 2 < 3 < 4, 5
Relative Bench Press (kg/kg)	31	0.98 ± 0.15 (0.68 - 1.32)	48	1.14 ± 0.14 (0.85 - 1.40)	55	1.21 ± 0.15 (0.88 - 1.50)	48	1.28 ± 0.16 (0.79 - 1.66)	26	1.28 ± 0.17 (0.95 - 1.49)	1 < 2 < 4, 5 1 < 3
1-RM Prone Row (kg)	31	70.9 ± 10.1 (52.5 - 92.5)	48	83.5 ± 10.2 (65 - 102.5)	55	91.1 ± 10.1 (70 - 115)	48	97.6 ± 12.4 (67.5 - 122.5)	26	100.0 ± 11.2 (75 - 122.5)	1 < 2 < 3 < 4, 5
Relative Prone Row (kg/kg)	31	0.94 ± 0.12 (0.76 – 1.18)	48	1.02 ± 0.11 (0.77 – 1.21)	55	1.06 ± 0.10 (0.80 – 1.27)	48	1.10 ± 0.12 (0.76 – 1.33)	26	1.12 ± 0.10 (0.93 – 1.28)	1 < 2 < 4, 5 1 < 3
Bench Press / Prone Row Ratio (%)	31	104.1 ± 14.4 (72.2 - 132.0)	48	112.4 ± 10.4 (91.3 - 134.9)	55	113.8 ± 8.8 (86.2 - 131.8)	48	116.6 ± 10.6 (93.3 - 142.9)	26	114.3 ± 9.0 (97.3 - 130.1)	1 < 2, 3, 4, 5

The numbers in parentheses in column headings relate to the numbers used for illustrating significant ($p<0.05$) differences in the post-hoc analysis between age categories

Table 2. Anthropometric and Physical Characteristics of Academy Rugby League Backs and Forwards by Age Category

	Under 16s (1)		Under 17s (2)		Under 18s (3)		Under 19s (4)		Under 20s (5)		
Backs	**N**	**Mean ± SD**	**N**	**Mean ± SD**	**N**	**Mean ± SD**	**N**	**Mean ± SD**	**N**	**Mean ± SD**	**Post-hoc**
Height (cm)	31	173.1 ± 8.2*	23	173.4 ± 4.1*	28	176.7 ± 5.9*	22	179.3 ± 5.4	13	180.1 ± 4.9	1 < 4, 5
Body Mass (kg)	31	68.4 ± 8.6*	23	75.4 ± 7.0*	28	78.5 ± 7.6*	22	81.8 ± 8.0*	13	85.0 ± 6.3*	1<2, 3, 4, 5; 2<5
∑ 4 Skinfolds (mm)	31	30.4 ± 5.9*	23	31.4 ± 6.2*	28	32.2 ± 7.9*	22	30.5 ± 6.9*	13	31.9 ± 7.4*	
Vertical Jump (cm)	30	48.1 ± 4.6*	23	50.5 ± 6.0	24	52.6 ± 5.7*	21	54.0 ± 6.2	13	54.4 ± 6.1	1 < 3, 4, 5
10m Sprint (s)	30	1.78 ± 0.06*	20	1.78 ± 0.04*	22	1.78 ± 0.05	16	1.79 ± 0.07	12	1.76 ± 0.07*	
20m Sprint (s)	30	3.07 ± 0.11*	20	3.07 ± 0.07*	22	3.06 ± 0.09	16	3.04 ± 0.08*	12	2.99 ± 0.10*	
Estimated VO2max ($ml.kg^{-1}.min^{-1}$)	27	47.5 ± 3.0	19	48.5 ± 2.1	24	49.1 ± 2.2	19	48.9 ± 2.7	12	49.1 ± 2.8	
1-RM Squat (kg)	14	94.9 ± 25.7	19	118.1 ± 18.8	24	129.6 ± 16.8	21	132.1 ± 20.2	12	136.9 ± 21.0	1 < 2, 3, 4, 5
Relative Squat (kg/kg)	14	1.33 ± 0.32	19	1.56 ± 0.22	24	1.65 ± 0.18*	21	1.61 ± 0.18	12	1.59 ± 0.21	1 < 2, 3, 4, 5
1-RM Bench Press (kg)	15	70.9 ± 15.0	19	89.3 ± 12.6	24	98.5 ± 13.8*	21	110.0 ± 16.3	12	112.8 ± 15.8	1 < 2< 3, 4, 5
Relative Bench Press (kg/kg)	15	0.99 ± 0.18	19	1.18 ± 0.13	24	1.24 ± 0.13	21	1.34 ± 0.13*	12	1.32 ± 0.15	1 < 2, 3, 4, 5; 2 < 4
1-RM Prone Row (kg)	15	68.9 ± 11.6	19	79.4 ± 10.5*	24	86.8 ± 10.4*	21	93.0 ± 12.4*	12	97.0 ± 11.0	1, 2 < 3, 4, 5
Relative Prone Row (kg/kg)	15	0.96 ± 0.12	19	1.05 ± 0.11	24	1.09 ± 0.10	21	1.13 ± 0.10	12	1.13 ± 0.07	1 < 3, 4, 5
Forwards	**Under 16s (1)**		**Under 17s (2)**		**Under 18s (3)**		**Under 19s (4)**		**Under 20s (5)**		**Post-hoc**
Height (cm)	37	177.7 ± 5.4	28	180.5 ± 5.5	33	181.9 ± 4.6	28	182.7 ± 5.0	14	180.1 ± 5.7	1 < 3, 4
Body Mass (kg)	37	80.9 ± 9.7	28	85.7 ± 8.6	33	90.9 ± 8.1	28	94.1 ± 7.7	14	92.6 ± 8.8	1 < 3, 4, 5; 2 < 4
∑ 4 Skinfolds (mm)	37	42.7 ± 14.1	28	40.5 ± 15.1	33	42.9 ± 12.8	28	43.5 ± 14.2	14	39.5 ± 9.1	
Vertical Jump (cm)	37	43.8 ± 5.0	27	48.0 ± 5.6	32	49.1 ± 5.2	24	51.2 ± 4.4	12	51.0 ± 4.1	1 < 2, 3, 4, 5
10m Sprint (s)	37	1.85 ± 0.06	25	1.83 ± 0.07	27	1.81 ± 0.06	23	1.83 ± 0.08	10	1.82 ± 0.04	
20m Sprint (s)	37	3.18 ± 0.09	25	3.16 ± 0.11	27	3.11 ± 0.11	23	3.14 ± 0.12	10	3.16 ± 0.07	
Estimated VO2max ($ml.kg^{-1}.min^{-1}$)	37	47.1 ± 3.7	27	48.9 ± 3.2	31	48.8 ± 3.3	25	48.3 ± 3.2	11	48.6 ± 3.0	
1-RM Squat (kg)	16	105.2 ± 17.3	28	124.9 ± 18.8	31	136.9 ± 14.2	24	143.7 ± 17.9	14	151.2 ± 21.6	1 < 2< 3, 4, 5
Relative Squat (kg/kg)	16	1.32 ± 0.19	28	1.46 ± 0.22	31	1.51 ± 0.17	24	1.55 ± 0.23	14	1.65 ± 0.29	1 < 3, 4, 5
1-RM Bench Press (kg)	16	76.8 ± 10.9	28	96.0 ± 13.6	31	107.5 ± 15.3	27	115.6 ± 16.3	14	115.5 ± 15.3	1 < 2< 3, 4, 5
Relative Bench Press (kg/kg)	16	0.97 ± 0.12	28	1.12 ± 0.14	31	1.19 ± 0.16	27	1.23 ± 0.17	14	1.25 ± 0.18	1 < 2, 3, 4, 5
1-RM Prone Row (kg)	16	72.6 ± 8.5	28	86.3 ± 9.3	31	94.3 ± 8.6	27	101.2 ± 11.4	14	102.5 ± 11.2	1 < 2 < 3 < 4, 5
Relative Prone Row (kg/kg)	16	0.92 ± 0.12	28	1.01 ± 0.10	31	1.04 ± 0.10	27	1.08 ± 0.12	14	1.11 ± 0.11	1 < 3, 4, 5; 2 < 5

* Sig difference between backs and forwards ($p<0.05$); The numbers in parentheses in column headings relate to the numbers used for illustrating significant ($p<0.05$) differences in the post-hoc analysis between age categories