Do physical qualities influence the attainment of professional status within elite 16-19 year old rugby league players?

Abstract

Objectives: The current study retrospectively compared the physical qualities of elite academy rugby league players (aged 16-19 years) by career attainment level (i.e., academy or professional).

Design: Retrospective cross-sectional and longitudinal design

Methods: Eighty-one academy rugby league players were assessed for physical qualities (height, body mass, skinfolds, speed, momentum, vertical jump, Yo-Yo Level 1 and 1-RM squat, bench press and prone row) at the Under 17-19 age categories between 2007 and 2012. Player's career attainment level was determined in 2014. Longitudinal changes in physical qualities between Under 17-19s were compared by career attainment level.

Results: Professional players demonstrated moderate significant advantages for height (d=0.98) and 1-RM squat (d=0.66) at the Under 17s, 1-RM bench press (d=0.76) at the Under 18s and 1-RM prone row (d=0.73) at the Under 19s age categories when compared to academy players. When assessed longitudinally (Under 17s-19s), professional players significantly outperformed academy players for 1-RM squat (η^2=0.20). Professional players also demonstrated greater increases in body mass (8.2 vs. 2.9 kg) and 10 m momentum (47 vs. 17 kg.s^{-1}) than academy players between the Under 17s and 19s.

Conclusions: Advanced physical qualities, particularly height and absolute strength, within 16-19 year old players may contribute to attaining professional status in rugby league. Further, the development of body mass and momentum for players within an academy is an important consideration in the progress towards professional rugby league. Therefore, practitioners should aim to identify and develop the physical qualities, especially size and strength, within academy rugby league players.

Key Words: Talent identification, talent development, academy, strength

Introduction

In recent years the focus on talent identification (TID) and development (TDE) of youth athletes has increased with many national governing bodies and professional clubs now investing considerable resources into this process.[1,2] TID and TDE research aims to provide an understanding of the factors that differentiate between playing levels (i.e., identification) and inform practitioners of the importance of certain characteristics to optimize training programme design (i.e., player development). Although these are the aims of TID research, most studies to date are limited as they only compare differing performance levels at one-off time points, usually within junior levels, using cross-sectional research designs (e.g., [3,4]). Such studies assume that current performance capabilities and discrepancies between performance levels in junior populations can therefore help predict potential success in adulthood.[5] However, to advance our understanding of the factors that contribute to TID and TDE, player characteristics should be prospectively or retrospectively tracked from players who attain the highest possible level of performance (i.e., professional).

Recent research in rugby league[6] and soccer[7,8] has retrospectively tracked the career attainment (i.e., amateur, academy, professional) of players selected to a TID programme during adolescence into adult professional sport. For example, Till and colleagues[6] assessed anthropometric and fitness characteristics of junior rugby league players between 2005-2007 when players were aged between 13-15 years and tracked their career attainment in 2008 (players aged 16 years) and 2013 (players aged 21 years). Findings showed that advanced fitness characteristics (i.e., speed, lower body power and agility) at adolescent ages differentiated between those players that attained professional status compared with their amateur peers[6] which was also consistent with findings in youth soccer.[7] However, advanced size in adolescent rugby league[6] and soccer[7,8] did not differentiate between career attainment levels, therefore questioning the selection of youth players based on body size. Such research suggests that advanced physical qualities within junior athletes can provide useful information for TID and TDE purposes. However, this research is only limited to athletes under 16 years of age. Instead, understanding the factors that may contribute to future adult attainment from within elite academy programmes (i.e., 16-19 years) may aid TID and TDE programmes further. Also, current studies rely on cross-sectional data that fails to examine the change and development of

characteristics. Understanding how physical qualities improve over period of time may specifically inform training development practices in the development of future professional athletes.[9]

Rugby League is a collision sport played worldwide from local recreation to professional levels across a range of junior to senior age groups.[10] The sport involves frequent high-intensity activities (e.g., sprinting, tackling, ball carrying) separated by periods of lower intensity activity (e.g., repositioning.[10,11] Therefore, players are required to have highly developed strength, speed, power, agility and aerobic fitness.[12,13] In the United Kingdom (UK), professional rugby league clubs employ an elite academy system whereby players aged between 16 and 19 years train and compete in the pursuit of a professional contract. A range of research is available within players of this age range (e.g.,[14,15]) but no study has evaluated the impact of physical qualities within academy aged players on subsequent career attainment level in rugby league. Therefore, the aims of the current study were (1) compare the differences in physical qualities in 16-19 year old elite academy rugby league players between career attainment level, notably whether the player's highest level of performance was academy or professional level; and (2) evaluate the longitudinal development of physical qualities across three age categories (i.e., Under 17s, 18s and 19s) between career attainment level.

Methods

A total of 81 academy rugby league players who were part of a UK Super League club's academy programme between 2007 and 2012 participated in the study. Players were selected from three annual-age categories (Under 17s, n=50; 18s, n=59; and 19s, n=49), meaning some players were assessed on two (n=29) or three (n=25) occasions. Following involvement in the academy programme, players were tracked in September 2014 (age = 22.2 ± 1.2, range = 20.2-24.7 years) to identify their career attainment level, which was defined as either a) 'professional', players who played professional Super League rugby league (i.e., the highest playing standard within the UK); or (b) 'academy', players who did not play professional Super League rugby league. For the purposes of this study, players were compared between professional and academy levels. Part 1, consisted of a cross-sectional analysis between professional and academy players at the Under 17, 18 and 19 age categories. For part

2, the players who had three consecutive years of data (n=25) were evaluated on a longitudinal basis by career attainment level.

All academy rugby league players undertook an annual fitness assessment in November each year as used in previous research.[15,16] All experimental procedures were approved by the Leeds Beckett University Ethics Committee with informed and parental consent (for players younger than 18 years) provided along with permission from the rugby league club. The annual fitness assessment was conducted by the lead researcher across two testing sessions. Testing session one consisted of field based assessments of speed (10 and 20 m sprint) and endurance (Yo-Yo intermittent recovery test level 1; Yo-Yo IRTL1) while session two included anthropometric (height, body mass and sum of 4 skinfolds), vertical jump and 1-RM strength (back squat, bench press and prone row) measures. All testing was preceded by a standardized warm up including jogging, dynamic movements and stretches and full instructions and demonstrations of the assessments. Typical error measurements and intra-class correlation coefficients for each assessment are presented in previous research[15] and all measurement reliability and objectivity conformed to published expectations.[17]

Height was assessed using a Seca Alpha stand (Seca, Birmingham, UK) to the nearest 0.1 cm. Body mass was assessed using calibrated Seca alpha (model 770) scales to the nearest 0.1 kg with participants wearing only shorts. Sum of four skinfolds (biceps, triceps, subscapular, suprailliac) were measured using calibrated skinfold callipers (Harpenden, British Indicators, West Sussex, UK) in accordance to Hawes and Martin.[18] Sprint speed was assessed using electronic timing gates (Brower Timing Systems, IR Emit, Draper, UT, USA) at 10 and 20 m with players positioned 0.5 m behind the start line and instructed to start in their own time. Participants performed three 20 m sprints, separated by 3 minutes rest with the quickest sprint time recorded to the nearest 0.01 s. Ten metre momentum ($kg.s^{-1}$) was calculated by multiplying body mass by 10 m sprint velocity (distance / sprint time; $m \cdot s^{-1}$).[12] Lower body power was assessed via a countermovement jump using a just jump mat (Probotics, Huntsville, AL, USA). The countermovement jump involved players standing with their hands positioned on the hips, squatting to their own selected depth and then explosively jumping as high as possible. Participants performed three maximal jumps separated by 60 s rest with the highest of the three jumps measured to the nearest 0.1 cm.[19] Endurance capacity was assessed via the Yo-Yo IRTL1

whereby players were required to run 20 m shuttles, followed by a 10 s rest interval, keeping to a series of beeps.[20] Throughout the test the running speed progressively increased and the test was terminated when participants reached volitional exhaustion or missed two consecutive beeps. Each participant's total running distance was then recorded. The ICC and CV for the Yo-Yo IRTL1 of r = 0.98 and CV = 4.6% has previously been published.[20]

Lower- and upper-body strength was assessed via 1-RM back squat, bench press, and prone row. All participants were experienced in these exercises and any player who failed to demonstrate correct technique, determined by the lead researcher, were not included in the testing (i.e., 9 participants were not included for 1-RM squat). Prior to 1-RM strength assessments, a warm-up protocol of 8, 5, and 3 repetitions was conducted with self-selected loads. Each participant then had three attempts to achieve a 1-RM score with 3 minutes rest allowed between attempts. For the 1-RM squat, each participants had to squat until the top of the thigh was parallel with the ground, with a neutral back position and heels on the ground, before returning to a standing position. For the 1-RM bench press, participants lowered a barbell to touch the chest and then pushed the barbell until elbows were locked out.[15] For the prone row, participants lay face down on a bench with the bench height determined by the players reach when arms were fully extended. Participants then had to pull the barbell towards the bench and the lift was included if both sides of the barbell touched the bench.[15] Following all assessments, relative squat, bench press and prone row was calculated by dividing the 1-RM score by the participants body mass.

Mean and standard deviation (SD) scores were calculated for all dependant variables according to professional or academy career attainment level. To examine the differences in physical qualities between professional and academy players at each annual-age category (i.e., Under 17s, 18s, 19s) an independent t-test was applied with Cohen's d effect sizes and 90% confidence intervals.[21] Cohen's d effect sizes were classified as 0–0.19 is trivial; 0.2–0.59 is small; 0.6–1.19 is moderate; 1.2–1.99 is large; and >2.0 is very large.[22] To analyse the players with data across three time points (i.e., Under 17s, 18s and 19s) a repeated measures multivariate analysis of variance test (RM MANOVA) was applied. Bonferroni pairwise comparisons were conducted to examine univariate effects between each dependent variable. Partial eta squared (η^2) effect sizes were also calculated and interpreted as

0.01 = small, 0.06 = medium and 0.14 = large.[21] All analyses were conducted with SPSS version 21.0 with significance levels set at $p<0.05$.

Results

Table 1 presents the mean and SD for the physical qualities of academy rugby league players according to academy and professional career attainment level. Independent t-tests identified significant differences between professional and academy players for height and 1-RM squat at the Under 17s, 1-RM bench press at Under 18s and 1-RM prone row at Under 19s. Effect sizes identified moderate effects for height, squat and prone row, and small effects for body mass, 20 m sprint, 10 m momentum, Yo-Yo IRTL1 and bench press at Under 17s. At Under 18s, small effects were found for height, body mass, sum of skinfolds, 20 m sprint, 10 m momentum, Yo-Yo IRTL1, vertical jump, 1-RM squat and prone row with moderate effects shown for 1-RM bench press. At the Under 19s, small effects were found for height, body mass, 10 m momentum, vertical jump, 1-RM bench press and squat with moderate effects shown for 1-RM prone row. Professional players outperformed academy players for all measures where significance and effect sizes were shown.

Insert Table 1 near here

Table 2 presents the longitudinal data for players assessed across the three time points (i.e., Under 17s, 18s, 19s). RM MANOVA showed a significant large effect between academy and professional players for 1-RM squat (p=0.027, η^2=0.20) with professional players significantly stronger across the three time points. For career level x time interaction, significant large effects were found for body mass (p=0.009, η^2=0.23), sum of four skinfolds (p=0.03, η^2=0.18), 10 m momentum (p=0.007, η^2=0.24), Yo-Yo IRTL1 (p=0.023, η^2=0.16), relative squat (p=0.023, η^2=0.18) and relative prone row (p=0.022, η^2=0.18). Findings demonstrated that professional players increased body mass and 10 m momentum the most across the three time points. Academy players reduced sum of four skinfolds and improved Yo-Yo IRTL1, relative squat and prone row more than professional players across the three years.

Insert Table 2 near here

Discussion

The present study compared the physical qualities and longitudinal development of physical qualities in academy (16-19 years) rugby league players according to career attainment level (i.e., professional or academy at 20 years of age or above) developing upon previous work in rugby league[6] and soccer.[7,8] Overall, findings showed professional players outperformed academy players on a range of physical qualities with the size in the difference dependent upon age category. Moderate differences were specifically identified for height and absolute strength (i.e., 1-RM bench press, squat and prone row). In addition, the improvement of body mass and 10 m momentum in professional players was superior to academy players between the Under 17s and 19s age categories. However, academy players reduced sum of four skinfolds and improved Yo-Yo IRTL1, relative squat and prone row more than professional players during the same period.

Height was significantly greater in professional compared to academy players at the Under 17s age category with small to moderate effects found across each age category for height and body mass. This finding demonstrates that increased height and body mass within academy rugby league players may contribute to attaining professional status coinciding with previous research suggesting body size contributes to an increased playing level in rugby league.[4,23] However, as height demonstrated the largest effects between the levels this may be a more important contributor towards career attainment in rugby league and may therefore be used as a potential identification measure within players aged 17-19 years, especially as this was the only measure assessed that was not trainable. However, current findings differ from previous research in younger (13-16 years) rugby league players whereby no differences were identified for body size with future career attainment.[6] Maturational processes may impact upon the development of body size in younger players[24,25] suggesting that height may only be a useful identification tool post maturation in rugby league player identification.

For physical performance, a range of characteristics (e.g., speed, Yo-Yo IRTL1, momentum and strength) demonstrated consistent small to moderate differences between professional and academy players. Superior scores were found within the professional players suggesting that advanced physical qualities are important for attaining the professional level in rugby league. This is supported

by previous research highlighting advanced physical qualities differentiate between playing levels.[4,12,23] Therefore, physical qualities may be important to consider in the identification and development of academy rugby league players. The largest differences between professional and academy players were found for momentum and absolute strength, suggesting these qualities may be the most important attributes for career attainment. Baker and Newton[12] demonstrated that increased momentum and strength were the best discriminators between elite and state based Australian adult rugby league players. Therefore the development of strength and momentum are important identification and development qualities for academy rugby league players, most probably due to the importance for the ball carrying and defensive efforts required within the sport to aid in attacking and defensive play.[26]

Longitudinal data, analysing players on three consecutive years (i.e., Under 17s, 18s and 19s), showed professional players significantly outperformed academy players for 1-RM squat. This finding further highlights the importance of lower body strength for the attainment of professional levels in rugby league. Lower body strength has previously been shown to be related to match performance (i.e., distance at high intensity efforts and repeated high intensity efforts[13]) and recovery post match-play[27] in rugby league. Therefore, current findings and previous evidence suggest that lower body strength should be a major focus of academy rugby league training programmes in their development of players towards the professional level.

The current study progressed on previous TID and TDE research by utilizing a longitudinal design and allowing physical qualities to be tracked over three time points in relation to career attainment. Findings demonstrated that body mass and 10 m momentum increased the most in professional (8.2 kg; 47 $kg.s^{-1}$) compared to academy (2.9 kg; 17 $kg.s^{-1}$) players. This finding suggests the development of body mass is an important consideration in the progress towards professional rugby league. Interestingly, academy players reduced sum of four skinfolds and improved Yo-Yo IRTL-1, relative squat and prone row more than professional players between Under 17s and 19s age categories. Greater improvements in these qualities may have occurred as they had a lower starting point and greater potential for change. However, it seems that the reduction of skinfolds and development of high-intensity running ability and relative strength may not be as important for future

career progression as the development of body mass and momentum. However, playing position was not considered in the current study, due to small participant numbers, which may influence the physical qualities required for future career attainment and should be considered in future research studies. Although all players undertook similar programmes, this may suggest that the trainability and adaptability of players is an important consideration. Although difficult to assess, practitioners should monitor the development of characteristics over time[9,25] to evaluate responsiveness to training.

Conclusion

This study identified that physical qualities can influence the career attainment of elite academy (16-19 years) rugby league players and should therefore be a consideration in the identification and development of rugby league players. Specifically, height, momentum and absolute strength showed the largest differences between future professional and academy players and may therefore be the most discriminating factors in contributing to career attainment in 16-19 year old players. In addition, lower body strength significantly differed between professional and academy players when compared across the three years with body mass and 10 m momentum improving more in professional players than academy players between Under 17s and 19s. Therefore, the development of strength and body size should be a major consideration in the training programmes of academy rugby league players for success within the adult professional game.

Practical Implications

- Physical qualities should be considered in the identification and development of elite 16-19 year old rugby league players due to their contribution to future career attainment.
- Height, momentum and absolute strength are the main differentiating qualities between future academy and professional players.
- Academy rugby league training programmes should focus on the development of body mass, momentum and strength in supporting future career attainment.

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References

1. Cobley S, Baker J, Schorer J. Identification and development of sport talent: A brief introduction to a growing field of research and practice, Chapter 1, in *Talent identification & development in sport: International perspectives,* Baker J, Cobley S, Schorer J editors, London, Routledge, 2012.
2. Williams AM, Reilly T. Talent identification and development in soccer. *J Sports Sci* 2000; 18(9): 657-667.
3. Gil SM, Zabala-Lili J, Bidaurrazaga-Letona I, et al. Talent identification and selection process of outfield players and goalkeepers in a professional soccer club. *J Sports Sci* 2014; 32(20): 1931-1939.
4. Till K, Cobley S, O'Hara J, et al. Using anthropometric and performance characteristics to predict selection in junior UK rugby league players. *J Sci Med Sport* 2011: 14(3): 264-269.
5. Vaeyens R, Lenoir M, Williams AM, et al. Talent identification and development programmes in sport: Current models and future directions. *Sports Med* 2008; 38(9): 703-714.
6. Till K, Cobley S, Morley D. et al. Retrospective analysis of anthropometric and fitness charactersitics associated with long-term career progression in rugby league. *J Sci Med Sport* 2015; 18(3): 310-314.
7. Le Gall F, Carling C, Williams M, et al. Anthropometric and fitness characteristics of international, professional and amateur male graduate soccer players from an elite youth academy. *J Sci Med Sport* 2010; 13(1): 90-95.
8. Ostojic SM, Castagna C, Calleja-González J, et al. The biological age of 14-year-old boys and success in adult soccer: do early maturers predominate in the top-level game? *Res Sports Med* 2014; 22(4): 398-407.
9. Till K, Cobley S, O'Hara J, et al. A longitudinal evaluation of anthropometric and fitness characteristics in junior rugby league players. *J Sci Med Sport* 2013; 16(5): 438-443.
10. Johnston RD, Gabbett TJ, Jenkins DJ. Applied sport science of rugby league. *Sports Med* 2014; 44(8): 1087-1100.
11. Gabbett TJ, King T, Jenkins D. Applied physiology of rugby league. *Sports Med* 2008; 38(2): 119-138.

12. Baker DG, 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* 2008; 22(1): 153-158.
13. Gabbett TJ, Seibold AJ. Relationship between tests of physical qualities, team selection, and physical match performance in semiprofessional rugby league players. *J Strength Cond Res* 2013; 27(12): 3259-3265.
14. Johnston RD, Gabbett TJ, Jenkins DG. Influence of an intensified competition on fatigue and match performance in junior rugby league players. *J Sci Med Sport* 2013; 16(5): 460-465.
15. Till K, Tester E, Jones B, et al. Anthropometric and physical characteristics of English academy rugby league players. *J Strength Cond Res* 2014; 28(2): 319-327.
16. Till K, Jones B, Darrall-Jones J, et al. Longitudinal development of anthropometric and physical characteristics within academy rugby league players. *J Strength Cond Res* 2014; 29(6): 1713-1722.
17. Hopkins WG. Measures of reliability in sports medicine and science. *Sports Med* 2000; 30(1): 1-15.
18. Hawes MR, Martin AD. Human Body Composition, Chapter 1 in *Kinanthropometry and exercise physiology laboratory manual: Tests, procedures and data second edition. Volume 1: Anthropometry*. London, Routledge, 2001.
19. Hunter JP, Marshall, RN. Effects of power and flexibility training on vertical jump technique. *Med Sci Sports Exerc* 2002; 34(3): 478-486.
20. Krustrup P, Mohr M, Amstrup T, et al. The yo-yo intermittent recovery test: physiological response, reliability, and validity. *Med Sci Sports Exerc* 2003; 35(4): 697-705.
21. Cohen, J. *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum. 1988.
22. Batterham AM, Hopkins WG. Making inferences about magnitudes. *Int J Sports Physiol Perform* 2006; 1(1): 50-57.

23. Gabbett TJ, Jenkins DG, Abernethy B. Relationships between physiological, anthropometric, and skill qualities and playing performance in professional rugby league players. *J Sports Sci.* 2011; 29(15): 1655-1664.
24. Till K, Cobley S, O'Hara J, et al. Anthropometric, physiological and selection characteristics in high performance UK junior rugby league players. *Talent Dev Excellence* 2010; 2(1): 193-207.
25. Till K, Cobley S, O'Hara J, et al. Considering maturation and relative age in the longitudinal evaluation of junior rugby league players. *Scand J Sci Med in Sport* 2014; 24(3): 569-576.
26. Waldron M, Worsfold PR, Twist C, et al. The relationship between physical abilities, ball-carrying and tackling among elite youth rugby league players. *J Sports Sci* 2014; 32(6): 542-549.
27. Johnston RD, Gabbett TJ, Jenkins DG, et al. Influence of physical qualities on post-match fatigue in rugby league players. *J Sci Med Sport* 2015; 18(2): 209-213.

28. Table 1. Physical Qualities between Academy and Professional Players at the Under 17s, 18s and 19s Age Categories

	Under 17s			Under 18s			Under 19s		
	Academy (n=37)	**Pro (n=13)**	**Cohens d ± 90% CI**	**Academy (n=41)**	**Pro (n=19)**	**Cohens d ± 90% CI**	**Academy (n=30)**	**Pro (n=19)**	**Cohens d (90% CI)**
Height (cm)	176.9 ± 5.5	181.8 ± 3.1**	0.98 ± 0.57	179.0 ± 5.3	181.8 ± 5.0	0.39 ± 0.66	180.5 ± 5.3	182.3 ± 5.2	0.34 ± 0.54
Body Mass (kg)	79.9 ± 10.3	84.5 ± 5.2	0.50 ± 0.52	84.7 ± 10.3	87.4 ± 8.9	0.27 ± 0.47	87.5 ± 9.9	90.8 ± 9.7	0.34 ± 0.49
Sum of 4 skinfolds (mm)	37.1 ± 14.3	34.6 ± 6.9	0.19 ± 0.68	39.0 ± 13.6	36.1 ± 7.6	0.24 ± 0.47	38.4 ± 15.6	36.9 ± 8.5	0.11 ± 0.52
10 m (s)	1.81 ± 0.06	1.80 ± 0.05	0.17 ± 0.54	1.80 ± 0.06	1.79 ± 0.06	0.17 ± 0.47	1.80 ± 0.05	1.80 ± 0.09	0.00 ± 0.53
20 m (s)	3.12 ± 0.09	3.10 ± 0.09	0.22 ± 0.53	3.11 ± 0.10	3.06 ± 0.10	0.50 ± 0.48	3.10 ± 0.09	3.09 ± 0.14	0.09 ± 0.54
10m Mom ($kg.s^{-1}$)	442 ± 54	470 ± 29	0.57 ± 0.53	466 ± 51	488 ± 46	0.45 ± 0.48	487 ± 51	503 ± 49	0.33 ± 0.54
Yo-Yo IRTL1 (m)	1436 ± 336	1553 ± 287	0.36 ± 0.54	1464 ± 354	1535 ± 322	0.21 ± 0.48	1475 ± 443	1443 ± 259	0.08 ± 0.53
Vertical Jump (cm)	48.8 ± 6.1	49.5 ± 4.9	0.12 ± 0.53	50.2 ± 5.8	51.8 ± 5.2	0.29 ± 0.48	51.5 ±5.2	53.3 ± 5.6	0.35 ± 0.54
Bench Press (kg)	92.1 ± 13.1	96.6 ± 14.4	0.34 ± 0.56	100.8 ± 14.2	111.9 ± 15.7**	0.76 ± 0.49	111.8 ± 15.4	115.6 ± 18.0	0.24 ± 0.56
Relative Bench Press ($kg.kg^{-1}$)	1.15 ± 0.13	1.12 ± 0.16	0.22 ± 0.55	1.19 ± 0.14	1.26 ± 0.14	0.50 ± 0.50	1.28 ± 0.17	1.26 ± 0.15	0.12 ± 0.55
Squat (kg)	119.1 ± 19.5	131.0 ± 14.0*	0.66 ± 0.55	131.6 ± 14.2	139.6 ± 17.2	0.52 ± 0.50	135.7 ± 18.1	143.9 ± 20.1	0.44 ± 0.56
Relative Squat ($kg.kg^{-1}$)	1.49 ± 0.24	1.53 ± 0.53	0.12 ± 0.54	1.56 ± 0.18	1.57 ± 0.17	0.05 ± 0.48	1.55 ± 0.20	1.57 ± 0.21	0.09 ± 0.54
Prone Row (kg)	81.8 ± 9.9	88.3 ± 10.3	0.65 ± 0.55	89.6 ± 9.2	94.2 ± 11.1	0.47 ± 0.50	94.3 ± 11.5	102.8 ± 12.2*	0.73 ± 0.55
Relative Prone Row ($kg.kg^{-1}$)	1.02 ± 0.10	1.03 ± 0.11	0.10 ± 0.55	1.06 ± 0.10	1.06 ± 0.09	0.00 ± 0.49	1.08 ± 0.12	1.12 ± 0.10	0.35 ± 0.54

29. Significant differences between annual-age categories; *p<0.05; **p<0.01; ***p<0.001

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33. Table 2. Longitudinal Development of Physical Qualities between Academy and Professional Rugby League Players

	Academy (n=15)			Professional (n=10)			Level		Level x Time	
	17s	**18s**	**19s**	**17s**	**18s**	**19s**	**P**	η^2	**P**	η^2
Height (cm)	179.8 ± 4.6	180.9 ± 4.5	181.6 ± 4.7	181.3 ± 1.8	182.8 ± 1.8	183.6 ± 2.3	0.24	0.06	0.41	0.03
Body Mass (kg)	84.7 ± 11.4	86.6 ±11.6	87.6 ± 11.2	84.3 ± 4.8	90.5 ± 2.1	92.5 ± 2.3	0.45	0.03	0.01	0.23
Sum of 4 skinfolds (mm)	42.3 ± 17.9	37.6 ± 15.6	35.9 ± 14.1	34.1 ± 6.3	37.7 ± 6.7	36.4 ± 7.5	0.62	0.01	0.03	0.18
10 m (s)	1.80 ± 0.06	1.80 ± 0.04	1.80 ± 0.05	1.79 ± 0.04	1.78 ± 0.06	1.79 ±0.07	0.51	0.02	0.78	0.01
20 m (s)	3.10 ± 0.06	3.09 ± 0.09	3.09 ±0.08	3.08 ± 0.09	3.08 ± 0.10	3.08 ± 0.12	0.72	0.01	0.86	0.01
10m Mom ($kg.s^{-1}$)	470 ± 61	480 ± 63	487 ± 61	471 ± 31	507 ± 18	518 ± 20	0.33	0.04	0.01	0.24
Yo-Yo IRTL1 (m)	1252 ± 262	1433 ± 247	1674 ±455	1512 ± 299	1459 ± 339	1560 ± 190	0.59	0.01	0.02	0.16
Vertical Jump (cm)	48.1 ± 6.2	51.6 ± 6.1	52.1 ± 5.6	49.5 ± 5.5	52.1 ± 5.5	54.6 ± 4.4	0.52	0.02	0.29	0.05
Bench Press (kg)	93.4 ± 13.4	106.8 ± 14.2	114.4 ± 15.6	100.0 ±14.4	115.4 ± 15.4	120.5 ± 15.9	0.24	0.06	0.64	0.02
Relative Bench Press ($kg.kg^{-1}$)	1.10 ± 0.12	1.23 ± 0.11	1.31 ± 0.13	1.18 ± 0.16	1.27 ± 0.16	1.30 ± 0.16	0.52	0.02	0.07	0.11
Squat (kg)	117.3 ± 20.1	134.0 ± 14.1	140.8 ± 11.0	134.3 ± 12.8	145.7 ± 16.0	151.8 ±16.0	0.03	0.20	0.40	0.03
Relative Squat ($kg.kg^{-1}$)	1.39 ± 0.20	1.55 ± 0.13	1.62 ± 0.14	1.59 ± 0.14	1.60 ± 0.16	1.64 ± 0.14	0.12	0.10	0.02	0.18
Prone Row (kg)	83.5 ± 12.3	93.0 ± 10.8	99.0 ±11.6	90.1 ± 9.3	100.0 ± 8.7	107.4 ± 10.8	0.09	0.12	0.62	0.02
Relative Prone Row ($kg.kg^{-1}$)	0.98 ± 0.10	1.07 ± 0.08	1.13 ± 0.09	1.07 ± 0.09	1.10 ± 0.09	1.16 ± 0.11	0.22	0.06	0.02	0.18

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