1 **Retrospective analysis of anthropometric and fitness characteristics associated with long-term**

2 **career progression in Rugby League**

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4 Kevin Till[1], Steve Cobley[2], John O'Hara[1], David Morley[1], Chris Chapman[3] & Carlton Cooke[1]

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6 [1]Research Institute for Sport, Physical Activity and Leisure, Leeds Metropolitan University,

7 Leeds, West Yorkshire, United Kingdom

8 [2] Discipline of Exercise & Sport Science, Faculty of Health Sciences,

9 The University of Sydney, New South Wales, Australia

10 [3]Rugby Football League, Red Hall, Leeds, United Kingdom

| | **Abstract** |
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2 **Objectives:** The current study retrospectively investigated the differences in anthropometric and

3 fitness characteristics of junior rugby league players selected onto a talent identification and

4 development (TID) programme between long-term career progression levels (i.e., amateur, academy,

5 professional).

6 **Design:** Retrospective design

7 **Method:** Former junior rugby league players (N=580) selected to a TID programme were grouped

8 according to their career progression level. Anthropometric (height, sitting height, body mass and sum

9 of four skinfolds), maturational and fitness (power, speed, change of direction speed and estimated

10 $\dot{V}O_{2max}$) assessments were conducted at 13-15 years. Multivariate analysis of covariance

11 (MANCOVA) analysed differences between career progression levels controlling for chronological

12 age.

13 **Results:** 57.1% and 12.1% of players selected to the TID programme progressed to academy and

14 professional levels in rugby league, respectively. Sum of four skinfolds (η^2=0.03), vertical jump

15 (η^2=0.02), 10m (η^2=0.02), 20m (η^2=0.02), 30m (η^2=0.02), and 60m (η^2=0.03) speed, agility 505 left

16 (η^2=0.06), agility 505 right (η^2=0.05) and estimated $\dot{V}O_{2max}$ (η^2=0.03) were superior within junior

17 players who progressed to professional compared to amateur levels. No significant differences were

18 identified between future academy and professional players for any measure.

19 **Conclusions:** Findings suggest that lower sum of four skinfolds and advanced fitness characteristics

20 within junior (13-15 years) rugby league players may partially contribute to long-term career

21 progression. Therefore, TID programmes within rugby league should aim to assess and develop body

22 composition and fitness characteristics, especially change of direction speed. However, TID

23 programmes should also consider technical, tactical and psycho-social characteristics of junior rugby

24 league players that may be important for long-term career progression.

25

26 **Key Words:** Talent identification, talent development, adolescence

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Introduction

1

2   In recent years, the emphasis on identifying and developing young talented athletes in the

3   pursuit of sporting excellence has led to national governing bodies and professional clubs investing

4   considerable resources into the process of talent identification and development (TID).[1,2] Traditionally,

5   TID research studies within youth sport (e.g., volleyball,[3] soccer[4]) have identified anthropometric and

6   fitness characteristics that distinguish between junior elite and sub-elite players. These studies (and

7   practice) work on the assumption that current performance capabilities and discrepancies between

8   selection levels in junior populations can help predict potential success in adulthood.[5] However, the

9   effectiveness of such TID programmes at adolescent stages is questionable with limited data available

10   that monitors the career progression of athletes through TID programmes into professional sport.[5] To

11   advance our understanding of the effectiveness of TID programmes and the factors that may contribute

12   to adult performance it would seem more valuable to prospectively track players, or retrospectively

13   trace their long-term career progression.[5,6]

14   Recent research in soccer[7,8] has retrospectively compared the anthropometric and fitness

15   characteristics of adolescent soccer players in relation to a player's attained career level (i.e., amateur,

16   professional or international). For example, Le Gall et al.[7] identified that junior soccer players aged

17   14-16 years who only attained amateur status were more mature than those who progressed to

18   professional and international levels. However, significant differences were observed for vertical jump

19   and 40m sprint performance that favoured the future professional and international compared to

20   amateur players. This research begins to suggest that fitness testing in adolescent athletes can provide

21   useful information in terms of predicting future career progression. However, similar investigations

22   retrospectively examining adolescent populations and related characteristics with long term career

23   progression in other sport contexts are limited, with no study available within rugby league.

24   Rugby league is a collision sport played at junior and senior levels around the world with

25   game popularity most established in Great Britain, France, Australia and New Zealand.[9] The sport

26   involves frequent periods of high intensity activity (e.g., sprinting, tackling) separated by lower

27   intensity activity (e.g., jogging).[9] Therefore, players are required to have highly developed strength,

28   speed, power, agility and aerobic fitness. [10] Previous research in the UK[11,12,13] and Australia[14,15,16] has

1   identified advanced anthropometric and fitness characteristics within junior players compared to the

2   normative population; between annual-age categories (i.e., Under 13, 14s, etc.); and according to

3   playing level (i.e., Regional and National players). Yet determining the relative importance and

4   influence that these characteristics have on future career progression has not been identified, which

5   would be informative for TID programmes within rugby league.

6   The UK's national governing body, the Rugby Football League (RFL), used a TID programme

7   named the Player Performance Pathway (PPP; see[17] for a detailed description) between 2005 and 2007

8   for players aged 13 and 15 years. All players selected to the PPP undertook an annual anthropometric

9   and fitness assessment each year, which allowed a retrospective analysis (in 2013) of the career

10   progression of players selected to the PPP. Therefore, the aims of the current study were (1) examine

11   the career progression levels of junior rugby league players originally selected to the PPP and (2)

12   investigate the differences in anthropometric and fitness characteristics in 13-15 year old rugby league

13   players between long-term career progression levels, notably whether the player's highest level of

14   performance attained was amateur, academy or professional. It was hypothesized that anthropometric

15   and fitness characteristics would be advanced in junior rugby league players that progressed to higher

16   career progression levels.

17

18   **Methods**

19   Former representative junior rugby league players (N=580) selected to the RFL's PPP between

20   2005 and 2007 participated in the study. Of these participants, 95, 195 and 290 players were selected

21   onto the PPP at the Under 13, 14 and 15 age categories, respectively. By July 2008, PPP players were

22   either: (a) selected to join a professional rugby league club's academy; (b) continued to play amateur

23   rugby league; or (c) no longer participate in the game. Through continued involvement at a

24   professional academy, players were then potentially able to progress into playing professional rugby

25   league within the European Super League. For the purposes of this study, players were divided into

26   three career progression levels for comparison, (1) not selected to an academy squad and classed as

27   'amateur'; (2) selected to a professional 'academy' but did not play Super League, and (3) played

1 'professional' rugby league by the end of the 2013 Super League season. Players were identified as

2 professional if they had played 5 or more Super League games.

3   All PPP players undertook an annual anthropometric and fitness assessment in July of the

4 respective junior years, with all protocols receiving institutional ethics approval with consent provided

5 by both players and parents/guardians. All assessments were conducted by Leeds Metropolitan

6 University sport science support team but were decided by the RFL. The protocol included standard

7 anthropometry (height, sitting height, body mass, sum of 4 skinfolds), maturation (age at peak height

8 velocity; PHV) and fitness (lower and upper body power, speed, change of direction speed, estimated

9 $\dot{V}O_{2max}$) assessments for each participant. Intra-class correlation coefficients and typical error

10 measurements for each measure are presented in previous research[11,12] and all measurement reliability

11 and objectivity conformed to published expectations.[18]

12   Anthropometric characteristics were collected prior to breakfast with participants wearing

13 only shorts. Participants' height and sitting height were measured using a Seca Alpha stadiometer, to

14 the nearest 0.1cm. Body mass was measured using calibrated Seca alpha (model 770) scales, to the

15 nearest 0.1kg. The sum of four skinfold thickness was determined using calibrated Harpenden skinfold

16 callipers (British Indicators, UK) with procedures in accordance with Hawes and Martin.[19] To measure

17 maturity status, an age at PHV prediction equation was used.[20] The 95% confidence interval associated

18 with this equation for boys is ±1.18 years.[20] Years from PHV were calculated for each participant by

19 subtracting age at PHV from chronological age.

20   Prior to fitness testing, a standardized warm-up was conducted, and all the players received

21 full instructions of the tests. The fitness tests were conducted in the order described. Running speed

22 was assessed over 10m, 20m and 30m and speed endurance was assessed over 60m using timing gates

23 (Brower Timing Systems, IR Emit, USA).[12] Times were recorded to the nearest 0.01s, with the

24 shortest time recorded during 3 trials, separated by 3 minutes rest, used for the sprint measurement.

25 Change of direction speed was assessed using the agility 505 test.[21] Participants were positioned 15m

26 from a turning point with timing gates positioned 10m from the start point. Players accelerated from

27 the starting point, through the timing gates, turned on the 15m line and ran as quickly as possible back

1   through the gates. Three attempts were performed on each foot, separated by 3 minutes rest, with

2   times recorded to the nearest 0.01s. To assess lower body power a vertical jump was measured using a

3   Takei vertical jump metre (Takei Scientific Instruments Co. Ltd, Japan). A counter-movement jump

4   with hands positioned on hips was used, with jump height measured to the nearest cm.[22] The vertical

5   jump score was the highest value recorded during three trials with 30s rest between jumps. The 2kg

6   medicine ball (Max Grip, China) chest throw was used to measure upper body power.[23] Participants

7   were seated with their backs against a wall and were instructed to throw the ball horizontally as far as

8   possible. Distance was measured to the nearest 0.1cm from the wall to where the ball landed with the

9   furthest of three trials used as the score. Maximal oxygen uptake ($\dot{V}O_{2\max}$) was estimated using the

10   multistage fitness test.[24] Keeping in time with a series of beeps, on a pre-recorded multistage fitness

11   test compact disc, players were required to shuttle run 20m. Player's running speed (i.e. frequency of

12   the beeps) increased progressively until they reached volitional exhaustion. Regression equations were

13   used to estimate $\dot{V}O_{2\max}$ from the level reached during the multistage fitness test.

14   Mean and standard deviation (SD) scores were calculated for all dependant variables

15   according to career progression level (i.e., amateur, academy, professional). To examine the

16   differences in anthropometric and fitness characteristics according to career progression level, a

17   multivariate analysis of covariance (MANCOVA) test was applied, with career progression level used

18   as the fixed factor and chronological age applied as the covariate. Chronological age was applied as a

19   covariate to control for the greater proportion of players at the older age categories (i.e., Under 13 =

20   95; 14s = 195; 15s = 290). Bonferroni pairwise comparisons were conducted to examine univariate

21   effects between each dependent variable. Partial eta squared (η^2) effect sizes were also calculated and

22   interpreted as 0.01 = small, 0.06 = medium and 0.14 = large according to Cohen.[25] All analyses were

23   conducted with SPSS version 19.0 with significance levels set at $p < 0.05$.

24

25   **Results**

26   From the 580 players originally selected onto the PPP between 2005 and 2007, 249 (42.9%)

27   players were classed as amateur, and 331 (57.1%) of players were academy players in July 2008 (i.e.,

1   when players were 16 years of age). From the 331 academy players, 70 players attained professional

2   status by the end of the 2013 Super League season demonstrating that 21.1% of academy players, and

3   12.1% of the players originally selected to the PPP progressed to a professional level.

4   Table 1 presents the mean and SD for the anthropometric and fitness characteristics of junior

5   rugby league players selected to the PPP according to amateur, academy and professional career

6   progression levels. MANCOVA analyses identified that chronological age, applied as a covariate, had

7   a confounding effect on all variables except medicine ball throw. MANCOVA analyses between

8   career progression levels revealed a significant overall difference ($F_{32, 1128}=3.48$, $p<0.001$, $\eta^2=0.11$)

9   demonstrating a medium-large effect size. Univariate analyses demonstrated significant effects for

10   career progression level on sum of four skinfolds, vertical jump, 10m, 20m, 30m and 60m sprint,

11   agility 505 left, agility 505 right and estimated $\dot{V}O_{2max}$. Medium effect sizes were identified for agility

12   505 left ($\eta^2=0.06$) and agility 505 right ($\eta^2=0.05$), with all other effect sizes classified as small.

13   Professional players significantly outperformed amateur players for the sum of four skinfolds, vertical

14   jump, 10m, 20m, 30m and 60m sprint, agility 505 left, agility 505 right and estimated $\dot{V}O_{2max}$.

15   Academy players outperformed amateur players for 60m sprint, agility 505 left, agility 505 right and

16   estimated $\dot{V}O_{2max}$. No significant differences were identified between professional and academy

17   players for any dependant variable.

18   ***Insert Table 1 near here***

19

20   **Discussion**

21   The present study examined the career progression levels of junior rugby league players

22   originally selected to a TID programme (i.e., PPP) and investigated the differences in anthropometric

23   and fitness characteristics of a large sample of junior rugby league players in relation to long-term

24   career progression level (i.e., amateur, academy or professional). Few studies have been able to

25   monitor the progress of athletes in talent development systems, which may be important to understand

26   the effectiveness and advance our understanding of the factors that contribute to future adult

1   performance.[5,6] This study begins to address these concerns and develops upon previous TID research

2   in rugby league.[12,15]

3   Overall, findings showed that 57.1% of players selected to the PPP progressed into a

4   professional club's academy system at 16 years and 12.1% went on to play professional rugby league.

5   These results suggest a low-moderate success ratio; similar to those reported within Russian and

6   German TID squads.[26] This suggests a large proportion of players selected to the PPP did not progress

7   to academy or professional level, questioning the efficacy surrounding TID programmes.[1,5,26] That

8   said, it is worth considering that the PPP context involved a large number of player selections per year

9   (i.e., total = 300, 100 at Under 13s, 14s, 15s) and that opportunities for all players to progress to a

10   professional level will never likely be feasible, when many sports employ pyramidal models of talent

11   development.[1] Further consideration of players not selected to the PPP, but yet who go on to progress

12   to play at professional levels would be particularly insightful, allowing comparisons between TID

13   programme and potentially alternative development pathways.

14   Overall significant effects were identified for career progression level between anthropometric

15   and fitness characteristics of junior rugby league players, demonstrating a medium-large effect size

16   (η^2=0.11). This suggests that advanced anthropometric and fitness characteristics within junior rugby

17   league players aged 13-15 years may be advantageous for future long-term career progression. These

18   findings are similar to research comparing current performance level within junior samples in rugby

19   league,[12,15,21] and other sports (e.g., volleyball,[3] soccer[4]) whereby anthropometric and fitness

20   characteristics improve with selection level. These findings suggest that advanced anthropometric and

21   fitness characteristics can differentiate between selection levels within junior populations and long-

22   term career progression levels.

23   For anthropometric and maturational characteristics, only sum of four skinfolds significantly

24   differed between career progression levels. No significant differences in height, body mass or age at

25   PHV suggest that size or maturation at 13-15 years did not influence career progression. No

26   differences in size or maturation have been found in other studies comparing TID junior samples in

27   rugby league[12,16,21] and other sports (e.g., volleyball[3]), with authors suggesting the sample had already

28   become relatively homogenous, due to performance demands at such levels. Although not directly

1   adhering to Le Gall et al.[7] whereby 'later maturers' progressed to professional and international levels,

2   current descriptive patterns do suggest that professional players (age at PHV = 13.80±0.72 years;

3   body mass = 67.1±12.8 kg) were 'less mature' and 'lighter' than future amateur players (age at PHV =

4   13.60±0.55 years; body mass = 70.7±13.5kg) at 13-15 years. This suggests that advanced size and

5   maturation status may not necessarily translate into higher levels of career progression in rugby

6   league. For sum of four skinfolds, professional players were significantly lower than amateur players

7   between 13 and 15 years. Although significance was demonstrated, effect sizes were small-medium

8   (η^2=0.03), suggesting that although lower skinfolds contribute to future career progression the effect is

9   minimal. However, sum of skinfolds could be used as an identification measure in rugby league with

10   players encouraged to achieve lower sum of skinfolds due to the relationship between lower body fat

11   with performance (e.g., speed, agility, power).[11]

12   All fitness measures, with the exception of medicine ball throw, showed significant effects

13   between career progression levels. Junior players who progressed to professional levels outperformed

14   those who progressed to amateur levels for vertical jump, 10m, 20m and 30m sprint with future

15   academy and professional players outperforming amateur players for the 60m sprint, agility 505 left,

16   agility 505 right and estimated $\dot{V}O_{2max}$. These findings are consistent with previous evaluations of

17   current performance by selection level in rugby league[12,16] and studies that track career progression in

18   soccer.[7,8] However, the magnitude of effect sizes was small for most variables other than change of

19   direction speed (i.e., Agility 505 left, η^2=0.06; right, η^2=0.05), which demonstrated the greatest effect

20   size. This suggests that change of direction speed may be the most discriminating physical

21   characteristic of junior players in determining career progression. A possible explanation for this may

22   be the demands of rugby league match-play involving constant accelerations and change of direction

23   due to the defensive line retreat required within rugby league match play.[9] Interestingly, no significant

24   fitness differences were identified between academy and professional players, consistent with findings

25   between future soccer international and professional players.[7] Although descriptive data suggests

26   some improved performance in future professional compared to academy players (e.g., vertical jump –

27   academy = 39.9 ±5.6, professional = 41.2 v 7.2cm) the lack of statistical significance demonstrates

1 that anthropometric and fitness characteristics may not be able to distinguish between players at 13-15

2 years who progress to academy and professional levels. This suggests that as playing level increases it

3 may be more difficult to identify distinguishing variables between more homogenous samples.[7,12,27]

4 However, the absence of assessments of specific rugby league fitness attributes (i.e., repeated sprint

5 ability), recently suggested as important for rugby league performance, [28] may be more sensitive to

6 differentiate between career progression levels (i.e., academy and professional). Therefore, although

7 fitness characteristics may contribute to long-term career progression and playing success in rugby

8 league, the small effect sizes and lack of differences between academy and professional players

9 suggest that fitness attributes combined with technical skills, tactical knowledge and psycho-social

10 development are important for future career progression as a professional rugby league player.[12]

11   The present study is not without limitations. Firstly, the PPP ceased at the Under 15s age

12 category and therefore anthropometric and fitness data was not available beyond this point. This may

13 have been informative in distinguishing variables that affect future career progression post 16 years. It

14 would have been more appropriate to measure maturation and fitness capacities (e.g., $\dot{V}O_{2max}$) more

15 directly than using estimation methods. The 60m sprint may not be the most appropriate assessment

16 within youth sport athletes with distances at a maximum distance of 40m commonly used. [29]Finally,

17 the lack of multi-disciplinary assessments, including technical, tactical and psychological attributes, is

18 a further limitation and broader challenge for research in this area. Integrating such measures may

19 provide additional and a more holistic insight into the characteristics of junior rugby league players

20 required for career success.

21

22   **Conclusion**

23   This study identified that 57% and 12% of players selected to the TID programme in junior

24 (Under 13 – 15) rugby league progressed to academy and professional levels respectively. No

25 differences were identified between career progression levels for maturation or size suggesting these

26 characteristics did not differentiate between future career progressions within an already identified

27 group of talented junior rugby players. Lower sum of four skinfolds and advanced lower body power,

1 speed, change of direction speed and estimated $\dot{V}O_{2max}$ at junior age categories contributed towards

2 long-term career progression level, as evidenced by increased characteristics within academy and

3 professional players when compared to amateurs. Therefore, considering these characteristics,

4 especially change of direction speed, is important for TID in rugby league, However, the small-

5 medium effect sizes and no significant differences between academy and professional level players

6 suggest that fitness characteristics only partially contribute towards academy and professional level

7 attainment and should be considered as part of a holistic approach to TID.

8

9 **Practical Implications**

10 • Rugby league practitioners should assess and develop body composition, speed, lower body

11 power, estimated $\dot{V}O_{2max}$ and in particular change of direction speed within junior rugby

12 league players for future career development.

13 • Height, body mass, maturation and upper body power at 13-15 years do not seem to contribute

14 towards long-term career progression in rugby league.

15 • Fitness characteristics only partially account for long-term career progression and TID

16 programmes should also consider technical, tactical and psycho-social characteristics of junior

17 rugby league players.

18

19 **Acknowledgements**

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Table 1. Anthropometric and fitness characteristics of junior rugby league players by career progression level

	Amateur (n=249)	Academy (n=261)	Professional (n=70)	Covariate Age	MANCOVA P	η^2
Age at PHV (Years)	13.60 ± 0.55	13.64 ± 0.58	13.80 ± 0.72	***		
YPHV	1.11 ± 0.88	1.22 ± 0.81	0.94 ± 1.14	***		
Height (cm)	174.2 ± 7.1	175.2 ± 6.8	174.1 ± 9.7	***		
Sitting Height (cm)	88.9 ± 4.0	89.1 ± 4.0	87.8 ± 5.8	***		
Body Mass (kg)	70.7 ± 13.5	70.9 ± 11.1	67.1 ± 12.8	***		
Sum 4 Skinfolds (mm)	41.6 ± 18.2	38.4 ± 15.5	33.4 ± 9.8 [a]	***	**	0.03
Vertical Jump (cm)	39.2 ± 4.9	39.9 ± 5.6	41.2 ± 7.2 [a]	**	**	0.02
Medicine Ball Throw (m)	5.7 ± 0.9	5.7 ± 0.9	5.8 ± 1.0			
10m (s)	1.90 ± 0.14	1.88 ± 0.13	1.85 ± 0.12 [a]	**	*	0.02
20m (s)	3.29 ± 0.19	3.25 ± 0.17	3.21 ± 0.16 [a]	***	**	0.02
30m (s)	4.61 ± 0.27	4.54 ± 0.23	4.51 ± 0.22 [a]	***	*	0.02
60m (s)	8.60 ± 0.56	8.43 ± 0.45 [a]	8.36 ± 0.49 [a]	***	**	0.03
Agility 505 L (s)	2.52 ± 0.16	2.47 ± 0.13 [a]	2.42 ± 0.12 [a]	***	***	0.06
Agility 505 R (s)	2.54 ± 0.15	2.48 ± 0.14 [a]	2.46 ± 0.12 [a]	***	***	0.05
Estimated $\dot{V}O_{2max}$ (ml.kg^{-1}.min^{-1})	47.6 ± 5.6	49.6 ± 4.9 [a]	49.8 ± 4.6 [a]	***	**	0.03

[a]Pairwise comparison, significantly different to Amateur; *P<0.05; **P<0.01; ***P<0.001