ABSTRACT

The purpose of this study was to compare anthropometric and physical performance phenotypes between current professional and amateur male Rugby Union (RU) players. The present study also sought to determine which anthropometric and physical performance variables were predictive of playing standard. Thirty professional and 30 amateur RU players performed Wattbike 6 s max effort and countermovement (CMJ) and squat jump (SJ) assessments, anthropometric measures were also taken. Dependant variables recorded and analysed included; body mass, stature, Σ8 site skinfolds, Wattbike absolute and relative peak power, CMJ and SJ average concentric force, jump height, peak velocity, time to peak force, rate of force development (RFD) and absolute and relative peak force and power. Professional players were heavier, taller and leaner than their amateur counterparts (P <0.05). Professional players performed significantly better in all physical performance measures except CMJ and SJ time to peak force, CMJ RFD and SJ relative peak force. Variables which were predictive of playing standard were; ∑8 skinfolds, CMJ peak velocity and Wattbike absolute and relative peak power (P <0.05). These findings indicate that the current body of male professional RU players are anthropometrically and physically superior to their amateur counterparts, although not all variables assessed here were predictive of playing standard. Data presented here indicate that ∑8 skinfolds, Wattbike absolute and relative power and CMJ peak velocity are predictive of playing standard whereas other anthropometric and strength and power variables are not.

KEY WORDS: Force, Talent Identification, Team Sports, Skinfolds, Elite

INTRODUCTION

In 1995, elite level Rugby Union (RU) turned professional. Professionalism in RU has allowed players to train on a full-time basis, and thus dedicate more time to physical preparation, in addition to technical and tactical training. Previous work has detailed the strength and conditioning (S&C) practices in elite northern and southern hemisphere RU [1,2] and separate work has investigated the influence of specific physical preparation interventions in elite and/or high level RU players [3–5].

Performance in RU is heavily dependent on the technical, decision making abilities, skill, and tactical awareness of the player. However, the necessary collision, grappling and evasion aspects of RU result in performance also being dependant on the physical capabilities of the player [6,7]. As such, it is reasonable to suggest that professional RU players at present, have superior anthropometric and physical performance capabilities to their amateur counterparts. Data are available to support this hypothesis, with previous work indicating that jumps based force and power variables, including peak force and power, differ between senior elite and elite junior level players [8]. Whilst this work provides useful and novel information, much of the body of similar work was conducted over 5 years ago. As such, this may not reflect the current battery of physical testing protocols employed in RU, advances in S&C practice and/or the current population of professional and amateur RU athletes.

Jumps based testing remains common place in elite RU [1], with squat jump (SJ) and countermovement jumps (CMJ) employed. The CMJ is thought to be reflective of strength including a stretch shorting cycle, and the SJ reflective of strength in the absence of the stretch shortening cycle [9]. The use of jumps testing using force plates has become increasingly popular, largely due to the fact software packages have been developed which are able to instantly calculate variables including; concentric and eccentric forces, rates of force development and absolute and relative forces. Another commonly employed testing protocol in RU is the Wattbike 6 s max effort [1], which is a simple and valid measure of absolute and relative peak power output [10]. These jumps and cycling tests have also been employed as load monitoring tools in RU [11]. Presently, there are limited normative data available on these jumps and cycle ergometer derived variables in professional and amateur level RU athletes. Data of this nature would provide useful information for S&C practitioners supporting RU athletes and may be used for talent identification purposes.

The purpose of the present study was to compare anthropometric and physical performance phenotypes obtained via Wattbike and force plate jumps testing between current professional and amateur RU players.

METHODS

Anthropometric, strength, and “power” orientated physical performance characteristics of full time professional and amateur Rugby Union players were compared. Professional players were contracted to and playing for a level 1 club competing in the English “Aviva Premiership”, amateur players were registered with and playing for teams competing at level 7 (regional) and British University and Colleges Sport leagues.

Data collection was conducted following all players pre-season periods. Players were familiar will all testing protocols including; Watt Bike 6 s max effort, CMJ and SJ.

Although not fully standardised, all participants performed low volume and intensity training the day prior to testing. Group warm ups were prescribed by an accredited strength and conditioning coach prior to all testing.

Subjects

Data were collected from 30 full time professional and 30 amateur Rugby Union players (total n=60). Descriptive characteristics of participants are presented in Table 1. Data were collected as a part of the routine sport science support provided to the players during the season, to which all players had consented. Therefore, usual appropriate ethics committee clearance was not required [12]. Nevertheless, to ensure confidentiality, all data were anonymized before analysis.

Procedures

Skinfold assessments

All assessments were performed in accordance with those set by the International Society for Advancement of Kinanthropometry (ISAK) [13] and all assessments were conducted by ISAK accredited practitioners. The sum of (Σ) the following eight sites (mm) were used for analysis; tricep, bicep, subscapular, abdomen, suprailliac, iliac crest, mid-thigh and medial calf.

Wattbike 6 s max effort

Testing was conducted on a commercially available cycle ergometer (Wattbike Pro, Wattbike Ltd, Nottingham, UK). Initially, participants completed a 5 min warm up at an intensity corresponding to rating of perceived exertion (RPE) 11–13 (light to somewhat hard) incorporating two acceleration phases of ~3 s commencing after 90 and 180 s with resistance set to level 8 throughout. Prior to testing participant's body mass was entered and a resistance for the test was recommended by the Wattbike software, as per manufacturers guidelines. Participants were then instructed to cycle maximally in a seated position for 6 s. Peak power (W) and peak power relative to body mass ($W \cdot kg^{-1}$) were recorded. Power calculations via Wattbike have previously been detailed [10].

Countermovement and squat jump assessments

Participants completed 3 maximal effort jumps with the hands-on hips. The jumps were completed with both feet on a series linked force plate (Kistler, type 9281CA, Winterthur, Switzerland) sampling at 1000Hz.

Kinetic data collection was managed through Bioware software (version 5.2.1.3). During countermovement jumps participants initiated a downward movement which was immediately followed by an upward movement. During squat jumps participants descended in to a "half squat" position and held this for 3 s before initiating an upward movement and take off, thus removing the stretch shortening cycle (SSC) [9].

The subjects' body weight (N) was measured on the force platform prior to jump tests. The onset of movement was taken from the point when the vertical force deviated 20N from body weight whilst take-off was when the vertical force dropped below 10N. Landing from the jump was determined from when the ground reaction force rose above 20N. The corresponding time points enabled us to determine movement time and flight time. Instantaneous vertical acceleration was determined from dividing the net vertical force by body mass, and differentiated to determine instantaneous vertical velocity. This in turn was differentiated to determine instantaneous vertical displacement relative to standing position before the jump was initiated. Jump height was determined from the peak displacement in the flight phase minus the displacement at the instant of take-off. Instantaneous power was determined by the product of the vertical force and vertical velocity.

For the countermovement jump the instant in which the displacement was most negative defined the end of the eccentric (or compression) phase and subsequent onset of the concentric phase. This also corresponds to the instant where vertical velocity was zero. For the squat jump all movement was performed concentrically from onset of movement to take-off. Average forces in the eccentric and concentric phases were calculated. Peak force (and relative peak force divide by body weight), time to peak force, peak power and peak velocity during the concentric phase were also recorded for further analysis. For the CMJ, rate of force development (RFD) was calculated as the average gradient of the force-time graph from the minimum value in the decent to the peak force in the concentric phase. For the Squat jump RFD was taken from body weight at the onset of movement to the peak force. Peak RFD in the CMJ reflects eccentric and concentric force development while in the squat jump it reflects concentric force development only.

Statistical analysis

Data are presented as mean ± standard deviation. Prior to analysis, dependant variables were verified as meeting required assumptions of parametric statistics. Data were analysed using mixed model univariate ANOVA tests (SPSS, version 20, Chicago, IL). ANOVA analysed differences on 2 levels; playing standard (professional and amateur) and position group (front row, second row, back row, inside back and outside back). If significant effects between playing standard, position group or interactions were observed *post-hoc* differences were analysed with the use of Bonferroni correction. The data set split by playing standard was also analysed independent of position group were also analysed using a student's T-test. The alpha level of 0.05 was set prior to data analysis.

A linear multiple regression was conducted to assess which variables may be predictive of both playing standard and position group. Pearson correlation coefficients (*r*) were used to assess relationships between anthropometric and physical performance variables.

In addition, probabilistic magnitude-based inferences about the true value of outcomes were employed [14]. Dependent variables were analyzed to determine the effect of the designated playing standard as the difference in each playing standard. To calculate the possibility of difference, the smallest worthwhile effect for each dependent variable was the smallest standardized change in the mean – 0.2 times the between-subject SD for baseline values of all participants. This method allows practical inferences to be drawn using the approach identified by Batterham and Hopkins [14]. Furthermore, standardized effect size (Cohen's d) analyses were used to interpret the magnitude of any differences.

RESULTS

Differences in anthropometric characteristics and physical performance variables between professional and amateur players are presented in tables 1 and 2. Significant correlations between anthropometric characteristics and physical performance variable in professional and amateur players are presented in table 3.

ANOVA revealed a significant playing standard*position interaction for body mass ($F_{(4, 58)} = 4.572$, $p = 0.003$) with professional second row and back row players being heavier than their amateur counterparts (p = 0.004, 15.3% and; 0.016, 13.0% respectively). A significant standard*position interaction was also observed for squat jump height ($F_{(4, 54)} = 4.816$, $p = 0.003$) with professional front row, inside backs and outside backs jumping higher than amateur players of the same position group (p < 0.001, 41.6%; 0.009, 24.2% and; 0.005, 22.8% respectively).

Effects of position group (irrespective of playing standard) were observed for body mass, ∑8 skinfolds, Wattbike relative peak force, CMJ and SJ height, average concentric force and peak velocity, CMJ peak force, SJ relative peak power and relative peak force (all $p < 0.05$). Details of where these significant differences lie are presented in Figures 1, 2 and 3. No other statistically significant differences were observed.

Linear multiple regression analyses indicated that the following variables were predictive of playing standard (all $p < 0.05$); ∑8 skinfolds, CMJ peak velocity and Wattbike peak and relative peak power. Furthermore, the following variables were predictive of playing position, irrespective of standard (all $p < 0.05$); ∑8 skinfolds and body mass.

DISCUSSION

The aim of the present work was to identify which strength and power related variables could differentiate between playing standard in current professional and amateur RU players.

From an anthropometric perspective, professional players were heavier, taller and had lower skinfolds than those playing at amateur level, with differences in body mass being present in second row and back row players. This is consistent with previous work indicating that those playing at higher standards were taller and heavier than those playing at lower standards [15,16]. Recent work has also indicated that academy level Rugby League players are taller and heavier than those playing at lower school level [17]. Here professional players were observed to be 9.9% heavier than amateurs, this is consistent with similar (yet older) work in Rugby League reporting that those playing tier 1 Rugby League are 8.9% heavier than those playing in tier 2. It appears that the current population of professional RU players are notably taller (~7 cm) and heavier (~18 kg) than those playing “first grade” RU before the year 2000. In addition, amateur players tested here were observed to be taller (~7 cm) and heavier (~15 kg) than those playing sub elite RU prior to the year 2000 [15]. This is perhaps reflective of both advances in strength and conditioning practice and changes in match characteristics of RU.

Whilst stature and body mass differed between professional and amateur players, these were not predictive of professional or amateur status. However, linear multiple regression analyses indicted that ∑8 skinfolds were predictive of professional and amateur playing status. This may be due to the fact professional players have more strictly imposed training regimens and dietary restrictions than amateur players.

Similar work conducted in Rugby League has indicated that full time professional players have less body fat and greater lean mass than those competing and training on a part time, semi-professional basis [18].

Across position groups, irrespective of playing standard, front row, second row, back row and inside backs were all heavier than outside backs, furthermore front row players were heavier than inside backs. This is likely attributable to the differing positional demands, and the necessity for particularly second and front row forwards to have high body mass'**.** In the current study, front row and back row players had greater skinfolds than outside backs, front row players also had greater skinfolds than inside backs. In addition, front row players had greater skinfolds than second rows and outside backs. In contrast, no differences in stature were observed across position groups. Anecdotally speaking, this may be reflective of the changes in the characteristics of RU, with inside and outside backs now having notable contributions in terms of aerial competition.

As detailed in Table 2, professional players out performed their amateur counterparts in many Wattbike, CMJ and SJ derived variables. This was expected given the physical requirements of RU and the enhanced provision of S&C services to professional level players. Whilst many physical performance metrics differed between professional and amateur players, the key variables which analyses revealed to be predictive of playing standard were; CMJ peak velocity and Wattbike peak and relative peak force.

It is logical that absolute forces achieved during a Wattbike 6 s max effort were predictive of playing standard. As previously stated, professional players were observed to be heavier than amateurs. It is likely that this was the primary contributing factor which enabled professionals to produce greater absolute forces in a short duration maximal effort. Given that professional players achieved ~25% greater peak power relative to body mass ($W \cdot kg^{-1}$), it is likely that this is attributable to the enhanced provision of S&C support. It is also reasonable to suggest that the greater velocities achieved by professional players are due to a greater exposure to S&C type training which involves plyometrics and ballistic exercises. Previous work has detailed the S&C practice in professional RU [1], and demonstrated that S&C coaches periodically implement plyometric and ballistic training methods. It is however, not known to what extent these training methods are conducted in amateur RU.

Correlations between anthropometric and physical performance metrics were observed across professional and amateur players. Within CMJ and SJ, body mass was positively correlated with average concentric and peak force, indicating heavier players are able to generate greater absolute forces. This is to be expected, as more raw force is required to move a greater mass. The ∑8 skinfolds were negatively correlated with CMJ and SJ height and peak velocity, indicating that leaner players were able to jump higher and faster. This is perhaps to be expected as leaner players carry less non-functional “fat mass” which may inhibit their ability to express force more quickly. Similar data have been reported in an Italian professional RU team, with lean mass being positively correlated with body weight SJ performance [19]. In addition, ∑8 skinfolds were negatively correlated with Wattbike relative peak power. This observation is logical, as peak force expressed relative to body mass is influenced by the total mass of the individual. As such, individuals with lower body fat achieved greater relative forces during Wattbike testing.

To conclude, the current professional male RU player is heavier, taller and leaner than his amateur counterpart, with key differences in body mass present between professional and amateur front and second row. Furthermore, ∑8 skinfolds appears to be predictive of professional or amateur playing status. In terms of physical performance, data presented here indicates that CMJ peak velocity and Wattbike peak and relative peak force are predictive of playing level.

The practical applications of this work lie in testing protocol selection and talent identification. For instance, data presented here indicate that RU athlete's ∑8 skinfold measures are predictive of playing standard, whereas other anthropometric measure such as body mass and stature are not. As such, when coaches and/or practitioners need objective data to support the transition of amateur or senior academy players to full time professional status, ∑8 skinfolds is more beneficial to assess than other, more simplistic anthropometric measures. However, it should be noted that using solely anthropometric data to support a player's transition is bad practice, such data should be utilised in conjunction with physical performance data. If objective strength and power data are needed to support such a transition, it is likely that simple measures such as jump height are insufficient. Where possible, jump derived variables peak velocity should be used. If force plate technologies and the aforementioned variables cannot be calculated, or heavier players are reluctant to perform jumps testing, Wattbike absolute and relative peak force should be utilised.

REFERENCES

1. Jones TW, Smith A, Macnaughton LS, et al. Strength and Conditioning and Concurrent Training Practices in Elite Rugby Union. *J strength Cond Res* 2016; 30: 3354–3366.

2. Jones TW, Smith A, Macnaughton LS, et al. Variances In Strength And Conditioning Practice In Elite Rugby Union Between The Northern And Southern Hemispheres. *J strength Cond Res*. Epub ahead of print 20 December 2016. DOI: 10.1519/JSC.0000000000001773.

3. West DJ, Cunningham DJ, Bracken RM, et al. Effects of resisted sprint training on acceleration in professional rugby union players. *J strength Cond Res* 2013; 27: 1014–8.

4. Cook CJ, Kilduff LP, Crewther BT, et al. Morning based strength training improves afternoon physical performance in rugby union players. *J Sci Med Sport* 2014; 17: 317–21.

5. West DJ, Cunningham DJ, Crewther BT, et al. Influence of ballistic bench press on upper body power output in professional rugby players. *J strength Cond Res* 2013; 27: 2282–7.

6. Dubois R, Paillard T, Lyons M, et al. Running and Metabolic Demands of Elite Rugby Union Assessed Using Traditional, Metabolic Power, and Heart Rate Monitoring Methods. *J Sports Sci Med* 2017; 16: 84–92.

7. Roberts SP, Trewartha G, Higgitt RJ, et al. The physical demands of elite English rugby union. *J Sports Sci* 2008; 26: 825–33.

8. Hansen KT, Cronin JB, Pickering SL, et al. Do force-time and power-time measures in a loaded jump squat differentiate between speed performance and playing level in elite and elite junior rugby union players? *J strength Cond Res* 2011; 25: 2382–91.

9. Van Hooren B, Zolotarjova J. The Difference Between Countermovement and Squat Jump Performances: A Review of Underlying Mechanisms With Practical Applications. *J strength Cond Res* 2017; 31: 2011–2020.

10. Herbert P, Sculthorpe N, Baker JS, et al. Validation of a six second cycle test for the determination of peak power output. *Res Sports Med* 2015; 23: 115–25.

11. Roe G, Darrall-Jones J, Till K, et al. To Jump or Cycle? Monitoring Neuromuscular Function in Rugby Union Players. *Int J Sports Physiol Perform* 2017; 12: 690–696.

12. Winter EM, Maughan RJ. Requirements for ethics approvals. *J Sports Sci* 2009; 27: 985.

13. Lohman T, Roche A, Martorel R. *Standardization of antropometric measurements*. Champaign, IL: Human Kinetics, 1988.

14. Batterham AM, Hopkins WG. Making meaningful inferences about magnitudes. *Int J Sports Physiol Perform* 2006; 1: 50–7.

15. Quarrie KL, Handcock P, Waller AE, et al. The New Zealand rugby injury and performance project. III. Anthropometric and physical performance characteristics of players. *Br J Sports Med* 1995; 29: 263–70.

16. 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: 153–8.

17. Jones B, Weaving D, Tee J, et al. Bigger, stronger, faster, fitter: the differences in physical qualities of school and academy rugby union players. *J Sports Sci* 2018; 1–6.

18. Jones B, Till K, Barlow M, et al. Anthropometric and Three-Compartment Body Composition Differences between Super League and Championship Rugby League Players: Considerations for the 2015 Season and Beyond. *PLoS One* 2015; 10: e0133188.

19. Pasin F, Caroli B, Spigoni V, et al. Performance and antrhropometric characteristics of Elite Rugby Players. *Acta Biomed* 2017; 88: 172–177.

ACKNOWLEDGEMENTS

None.

Figure Legends

Figure 1. Position group differences in body mass (panel A), ∑8 skinfolds, (panel B) and Wattbike relative peak force (panel C). * Significantly greater than outside back (p < 0.05), † significantly greater than inside back (p < 0.05), # significant lower than front row (p < 0.05) and + significantly greater than front row (p < 0.05).

Figure 2. Position group differences in countermovement jump; height (panel A), average concentric force (panel B), peak velocity (panel C) and peak force (panel D). * Significantly greater than outside back (p < 0.05), + significantly greater than front row (p < 0.05) and $ Significantly greater than second row (p < 0.05).

Figure 3. Position group differences in squat jump; height (panel A), average concentric force (panel B), relative peak power (panel C), relative peak force (panel D), and peak velocity (panel E). * Significantly greater than outside back (p < 0.05), + significantly greater than front row (p < 0.05) $ Significantly greater than second row (p < 0.05) and ^ significantly greater than back row (p < 0.05).