Six-year body composition change in male elite senior rugby league players

Running title: six-year body composition change in rugby players

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Abstract

This study investigated the change in body composition and bone mineral content (BMC) of senior rugby league players between 2008 and 2014. Twelve male professional rugby league players (age, 24.6±4.0 years; stature, 183.4±8.4 cm) received a DXA scan during pre-season in 2008 and 2014. Between 2008 and 2014, *very likely* increases in leg lean mass, total trunk and leg BMC, and a *likely* increase in arm BMC and *possible* increases in body mass, total and trunk fat mass, and total, trunk and arm lean mass were observed. *Unlikely* decreases and *unclear* changes in leg and arm fat mass were also found. *Large* negative correlations were observed between age and body mass (r=-0.72), lean mass (r=-0.70), fat mass (r=-0.61), and BMC (r=-0.84) change. Three participants (19.1 ± 1.6 years) increased lean mass by 7.0 – 9.3 kg. Younger players had the largest increases in lean mass during this period, although an older player (30 year-old) still increased lean mass. Differences in body composition change were also observed for participants of the same age, thus contextual factors should be considered. This study demonstrates the individuality of body composition changes in senior professional rugby players, while considering the potential change in young athletes.

Introduction

Rugby league (RL) is an intermittent high-intensity, contact team sport played internationally and domestically at professional, amateur and junior levels, mainly within Europe and Australasia (Johnston, Gabbett, & Jenkins, 2014). The body composition of RL players has recently been investigated, comparing differences between positions (Jones et al., 2016; Morehen, Routledge, Twist, Morton, & Close, 2015) ages (Till et al., 2016), level (Jones, et al., 2015) and changes over a competitive season (Harley, Hind, O'Hara, 2011; Georgeson, Weeks, McLellan, & Beck, 2012). These studies have shown that senior players are larger with more lean mass (LM) than junior players (Till et al., 2015), and elite players have more LM and less fat mass (FM) than sub-elite players (Jones et al., 2015). Given the aforementioned observations, it appears that having well developed LM is advantageous for RL, and should be a consideration for practitioners working within talent identification and development (Till, Jones, & Geeson-Brown, 2015), strength and conditioning coaches and nutritionist (Smith, Jones, Sutton, King, & Duckworth, *In Press*).

Despite the current research investigating the body composition of RL players, studies are limited within their designs due to one-off observations (Morehen et al., 2015), cross-sectional designs (Jones et al., 2015; Till et al., 2015) or observations over only one competitive playing season (Harley, Hind, & O’Hara, 2011; Georgeson et al., 2012). RL players are typically recruited into an academy system and then those identified with future potential will progress into senior teams (Till, Jones, & Geeson-Brown, 2015). Once in a senior team, players will compete until being released from their professional contract or they leave out of choice, due to injury or retirement. Thus some players may be in a senior team for 16 years (*B. Jones*, Unpublished observation). To date, it is unclear how body composition profiles change over long periods of time, throughout a RL players career. Furthermore, bone mineral content

(BMC) is a likely consideration for the long term health of a player, given the association between BMC and injury (e.g., bone fractures) (Nordström et al., 2005).

Whilst the presentation of mean (± standard deviation [*SD*]) changes in body composition (Harley, Hind, & O'Hara, 2011; Georgeson et al., 2012) provides the reader with an insight into the overall trend, it is unlikely to reveal the true inter-player variability that exists. For example, the longitudinal change for the sum of skin folds in rugby league academy players over 4-years has been shown to have a coefficient of variation (CV) of 2700% (Till et al., 2015). As such, the presentation of individual data alongside mean trends may provide useful reference data for those working within talent identification and development, and an insight into the respective inter-player variability.

To date, longitudinal changes in body composition and BMC determined using dual-energy X-ray absorptiometry (DXA), which provides an accurate assessment of total and regional body composition (Barlow et al., 2015) are not known in professional RL players. Therefore, the aim of this study was to investigate the mean and individual longitudinal change in body composition and BMC over a six-year period in professional RL players.

Methods

Subjects

Twelve male professional RL players (mean age, 24.6±4.0 years; stature, 183.4±8.4 cm in 2008), participated in the study. All subjects had been involved in the professional RL club's first team squad for a minimum of 12 months prior to the first DXA scan. All experimental procedures were approved by the University Faculty Research Ethics Committee with signed informed consent obtained along with permission from the RL club.

Design

A six-year longitudinal observational design was used to investigate the change in body mass (BM), body fat percentage, and BMC alongside total and regional (arms, legs, and trunk) FM and LM between 2008 and 2014. Subjects were scanned 2-3 weeks prior to their first competitive fixture (during the late phase of the pre-season training period; January – February) on both occasions. Body composition is expected to be optimal during this period of the season.

Methodology

Stature was measured using a stadiometer (SECA Alpha, Birmingham, UK) to the nearest 0.1 cm and BM was measured using calibrated electronic scales (SECA Alpha 770, Birmingham, UK) to the nearest 0.1 kg. All subjects were scanned in a fasted and euhydrated state (urine osmolality <700 $mOsmol \cdot kg^{-1}$) on the morning of a non-training day, as previously recommended (Nana, Slater, Hopkins, & Burke, 2012). Each subject received one total body DXA scan (Lunar iDXA, GE Medical Systems, UK) in 2008 and in 2014 on the same machine as previously described (Jones et al., 2015; Jones et al., 2016). All scans were undertaken by one skilled technologist and then analysed following the manufacturer's guidelines. The regions of interest were manually placed as previously described (Jones et al., 2015). Scan analysis was performed using the Lunar Encore software (Version 15.0). Scans acquired using older software (Encore versions 12.0-13.0) were reanalysed accordingly. The machine's calibration was checked and passed on a daily basis using the GE Lunar calibration hydroxyapatite and epoxy resin phantom. There was no significant drift in calibration for the study period.

Statistical Analyses

To investigate mean changes data are presented as means ± *SD* for body composition and BMC in 2008 and 2014. Analyses were conducted following log-transformation of the data to reduce bias arising from non-uniformity error and analysed for practical significance using magnitude-based inferences (Hopkins, Marshall, Batterham, & Hanin, 2009). The threshold for a change to be considered practically important (the smallest worthwhile change, SWC) was set at 0.2 x between-subject *SD*, based on Cohen's *d* effect size principle. The probability that the magnitude of change was greater than the SWC was rated as <0.5%, *almost certainly not*; 0.5-5%, *very unlikely*; 5-25%, *unlikely*; 25-75%, *possibly*; 75-95%, *likely*; 95-99.5%, *very likely*; >99.5% *almost certainly*. Where the 90% Confidence Interval (CI) crossed both the upper and lower boundaries of the SWC (ES ± 0.2), the magnitude of change was described as *unclear*. In order to examine the individual change across the 6 years, the percentage change in each DXA metric was plotted for each subject with error bars representing the CV for the metric as previously reported (Barlow et al., 2015). Where error bars crossed the SWC (0.2 x within-subject *SD*), the change was deemed *unclear* (Hopkins 2004). To help explain the individual change, Pearson correlations were undertaken to determine the size of the effect (Cohen, 2013) between age and; ΔBM, ΔLM, ΔFM, and ΔBMC.

Results

Mean body composition and BMC from 2008 and 2014 for senior male professional RL players are shown in Table 1.

Insert Table 1 near here

Individual change in total, trunk, leg and arm fat mass, lean mass and BMC are shown in Figure 1, considering the CV for the specific DXA measurement (Barlow et al., 2015) and the SWC.

Insert Figure 1 near here

Large effects were observed between age and; ΔBM, ΔLM, ΔFM, and ΔBMC, (*r* = -0.72, -0.70, -0.61, -0.84).

Discussion

The aim of this study was to investigate the mean and individual long-term change in body composition and BMC over a six-year period in professional RL players. On average, the group of subjects demonstrated increases in total and regional LM and BMC. In addition, a *possible* increase in BM, *unclear* change in percentage body fat, a *possible* increase in total and trunk FM and an *unclear* change in leg and arm FM was also observed. When analysed individually, the findings demonstrated the large between-player variability for the change in body composition over a six-year period.

Over the six-year period, a *possible* mean increase in total FM was observed as a result of increased trunk FM. If FM was adequate at baseline (2008), it is possible that an increase in FM might be detrimental to RL performance, given the need for an optimal power: weight ratio (Jones et al., 2015; Jones et al., 2016). Previous studies in RL have shown FM increased between pre and post season (13.59 ± 3.66 to 14.49 ± 4.05 kg; Harley, Hind, & O'Hara, 2011). Georgeson et al. (2012) also showed an increase in FM over the season (10.7 ± 3.1 to 11.0 ± 4.9 kg), with a further increase from the end of the season to the beginning of the subsequent preseason (to 11.4 ± 4.5 kg) in Australian RL players. This may be due to the lower frequency of resistance training during the in-season, in comparison to preseason (Till et al., 2015).

FM for subjects in this study were similar to that reported by Harley, Hind, & O'Hara (2011) and greater than Australian-based players in the study by Georgeson et al. (2012) possibly representing differences between Australian and English RL players. The six-year change observed in this study, alongside reported results from Harley, Hind, & O'Hara, (2011) and Georgeson et al. (2012) over seven- and twelve-months, suggests that FM may increase during the season and then reduce during preseason periods. As such, the FM change, as with other measures might represent a *net* change over the six-year period, while FM gains appear proportionate to the LM gains (given the overall BM change and unclear change in percentage body fat). Despite the observed mean increase in FM, subjects in this study have greater LM and less FM than reference data for age matched males (Hind, Gannon, Brightmore, & Beck, 2015).

A *possible* group increase in total LM across six-years was found, with the greatest increase observed in the legs (*very likely* increase). Till and colleagues (2015) previously observed significant differences between adolescent and senior RL players for leg LM, suggesting players require a greater period of time to develop the musculature of the lower-body. Harley, Hind, & O'Hara, (2011) and Georgeson et al. (2012) observed decreases in LM during the season, thus given the findings of this study, it is likely net annual increases exceeded losses experienced during the season. Harley, Hind, & O'Hara, (2011) and Georgeson et al. (2012) reported a 1-2% LM loss from pre to post season, whereas this study showed an approximate mean 0.7% net annual increase in LM. If it is accepted that players lose 1-2% of LM during the season (Harley, Hind, & O'Hara, 2011; Georgeson et al. 2012), the findings of this study suggest during preseason, RL players could aim to increase their respective LM by approximately 2% to stay in a positive balance. Specifically, the findings of this study may highlight the development potential of the lower limb musculature (in line with recommendations from Till et al. 2015) to a greater extent than the trunk and upper limbs. The direct translation of these findings for practitioners are the LM goals for RL players. Furthermore, if suboptimal practices (e.g., nutrition, training exposure or recovery) are occurring at present, practitioners can modify these to focus on the maintenance of LM when in season, knowing long term net increases can occur.

Over the six-year period a *very likely* increase in total BMC was observed, which could be attributed to increases in trunk, leg and arm BMC. Bone health has specific implications for RL players, given the contact and collision nature of the sport (Johnston, Gabbett, & Jenkins, 2014) and implicit injury risk (Georgeson et al., 2012). The demands of RL (Twist, Highton, Waldron, Edwards, Austin, & Gabbett, 2014) appear ideal conditions for bone mineralization (Lanyon & Rubin, 1984), thus may stimulate anabolic bone adaptation according to the Mechanostat theory (Schoenau & Fricke, 2007). The observed increase in bone mass, particularly during the phase of peak bone mass accrual, may have benefits for the long-term health of a player (e.g., reducing the risk of osteoporosis and fragility fractures) (Nordström et al., 2005).

Despite the observed mean trends in body composition, practitioners and researchers should be aware of the large inter-player variability. The mean overall change in LM is most likely a result of the increase observed for subjects four, eleven and twelve (age in 2008; 20, 17 and 20 years old, respectively), who observed an increase of 7.0 – 9.3 kg in LM over this period (Figure 1). Given the nature of this study, it is not possible to attribute an exact cause to these specific change, but possible explanations could relate to a players age (development) given the strength of the relationships between age and; ΔBM, ΔLM, ΔFM, and ΔBMC (r = -0.72, -0.70, -0.61, -0.84). The change could also be explained by genotype, their training history, previous injury, playing exposure, positional requirement or contextual RL requirements as determined by the coach or support staff, which are all beyond the scope of this study to establish. It should be noted that two subjects (i.e., subject seven and nine) of the same age (30 years) and position had a different LM (3.7 vs. -3.0 kg) change. Thus, factors beyond age should be considered when evaluating individual change, although younger players appear to have a greater capacity to increase LM.

Contextual factors may influence the desirability of having high LM, beyond an *adequate* amount. While LM may be important, all players are required to undertake a high volume of repeated sprint ability during a match (Austin, Gabbett, & Jenkins, 2011), thus mass (regardless of lean or fat) will increase the energy costs of the activity, and may negatively impact high-speed running ability (Darrall-Jones, Roe, Carney, Clayton, Phibbs, Read, Weakley, Till, & Jones, 2015). As such, a coach's style of play may influence the desired BM and body composition of an elite rugby player, to specifically adapt to the respective technical aims. For example, subject ten changed playing positions (from a positional forward to back) during the observational period, and had a 1.0 kg decrease in LM and no (0.1 kg) change in FM. Thus, positional changes should be considered when interpreting longitudinal data. It is likely contextual sporting factors are a key determinant to a players long-term change in body composition, and should be considered when interpreting athlete body composition profiles (Jones, Till, Manley, & McGuigan, 2016). Given the myriad of factors that could influence a player LM, practitioners should monitor the individual change of an athlete, in line with the requirements of the sport, while considering it is unlikely a decrease in LM and an increase in FM is optimal for any athlete (Jones et al., 2015).

For subjects four and twelve, in addition to the large increases in total LM, FM in their trunk region almost doubled over the six years (Figure 1). It is not clear if a positive (excessive) energy balance (given the FM increase) of this magnitude is needed for the observed concurrent LM change, as the metabolic basis for skeletal muscle growth is indicative of the relationship between rates of muscle protein synthesis and muscle protein breakdown, alongside specific exercise which have a profound effect on muscle protein metabolism (Tipton & Wolfe, 2001). Only one subject from this cohort had a loss in FM (subject six; prop aged 27 years old in 2008), while increasing LM over the six-year period, thus the concurrent increase in FM may be a requirement for most players aiming to increase LM. It is not clear what the specific aims of each subjects were during this observational period, for example a player may aim to 'bulk up', given the strong association with size and rugby success (Sedeaud et al., 2012; Till, Jones, McKenna, Whitaker, & Backhouse, 2016), thus an increase in FM may have been intentional. As such, given the optimal position and athlete specific body composition profile for a RL player is unknown, it may be a deliberately strategy to gain mass, regardless of the proportionate contribution from FM and LM. While considering body composition of athletes, the nutritional intake of players should be considered, which may support the development of LM, while managing FM gains (MacKenzie-Shalders, King, Byrne, & Slater, 2016), should this be the aim of the player.

For the three subjects who experienced large increases in LM, the mean LM for their respective playing position is 71.9 – 76.1 kg (Morehen et al., 2015). In 2008, when initial DXA scans took place, the LM for the three subjects were 78.7, 73.6 and 71.9 kg, which were 88.0, 82.9 and 78.9 kg in 2014, thus all subjects initially had greater LM than that reported by Morehen and colleagues (2015). Furthermore, the subjects who observed large increases in LM were positional backs (wing and centre/full-back positions). Of relevance, 19 years of age is the cut off within a RL academy (e.g., Under 19 age group) (Till, Jones & Geeson-Brown, 2015), before players are 'senior'. The respective findings demonstrate the potential development remaining in young RL players beyond the academy, especially considering the player who at 30 years of age in 2008 had an increased LM. It has previously been reported that backs mature later than forwards (Till, Cobley, O'Hara, Chapman, & Cooke, 2010; Till, Cobley, O'Hara, Chapman, & Cooke, 2013) and they may be identified based on their skill as opposed to physical attributes (Till et al., *In Press*). Within this sample, the subjects previously discussed were the youngest within the squad, thus it is not clear how they compare to forwards of the same age.

Although this study is the first to monitor the long-term change of body composition within RL players, it is not without its limitations. Firstly, the study has a small sample size, but given the nature of professional sport, players rarely remain at the same club for a prolonged period of time. Therefore, the sample of twelve subjects over a six-year period should be seen as a strength of the study. Secondly this study only performed two DXA scans, thus it is unclear when the body composition and BMC changes occurred. Furthermore, it is not clear at what point, if any, subjects experienced a plateau or possible decreases in body composition development. This study also only presented body composition and BMC for subjects, which may only be a small contributing factor to RL performance. As such, future studies should look to combine (physical, psychological and skill) performance measures with those reported in this study. Finally, the findings of this study are only representative of one club, which may have unique practices, thus it is not clear if larger or smaller body composition change occur in a larger cohort of RL players.

Conclusion

In conclusion, increases in BM, FM, LM and BMC were observed over a six-year period in professional RL players. Age was strongly related to body composition change, however, some senior (30 year old) players also gained LM. Given the importance of body composition for RL performance, practitioners should look to support body composition targets in line with the specific contextual sport demands for each athlete. This study has direct translation for the practitioner working in rugby by providing reference ranges for change. Furthermore, practitioners working in talent identification should be aware of the potential large increase in LM within professional senior players, thus limit the identification of future professional RL players on size alone.

Figure 1. Individual percentage change over a six-year period for senior male professional rugby league players in A) fat mass, B) lean mass, and C) BMC for 1) arms 2) legs 3) trunk and 4) total. Error bars represent the CV for the particular DXA metric (Barlow et al., 2015). The shaded area represents the SWC (0.2 x between subject standard deviation of measurement 1). Where the error bars lie outside the SWC the change is considered clear, while those inside are not.

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