Accepted: IJSM, April 2021

Body mass and body composition changes over 7 years in male professional rugby union team.

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Abstract

The purpose of this study was to investigate longitudinal body mass and body composition changes in rugby union players (n= 123) from one professional club, (i) according to position [forwards (n= 58) versus backs (n= 65)], (ii) analysis of players with 6 consecutive seasons of DXA scans (n= 21) and, (iii) to examine differences by playing status [academy and international], over 7 years. Players [mean age: 26.8y, body mass index: 28.9kg.m^2] received DXA scans at four-time points within each year. A modest (but non-significant) increase in mean total mass (0.8kg) for professional players was reflected by increased lean mass and reduced body fat mass. At all-time points, forwards had a significantly greater total mass, lean mass and body fat percentage compared to backs ($p< 0.05$). Academy players demonstrated increased total and lean mass and decreased body fat percentage over the first 3 years of senior rugby, although this was not significant. Senior and academy international players had greater lean mass and lower body fat percentage ($p< 0.05$) than non-international counterparts. Despite modest increases in total mass; reflected by increased lean mass and reduced fat mass, no significant changes in body mass or body composition, irrespective of playing position were apparent over 7 years.

Keywords: Body composition; Dual-energy X-ray absorptiometry; Athletes; Longitudinal analysis.

Introduction

Rugby Union (herein referred to as ‘rugby’) is a physically demanding, high-intensity, collision sport [1], with distinct differences in body mass required for playing positions [2]. Body composition in rugby is an important component to success, as power-to-body mass ratio underlies many of the sporting movements [3]. Previous research provides insight into compositional characterisation [4, 5], positional differences [1, 6], and inter-seasonal changes [1, 4]. Jones et al was the first to investigate longitudinal body composition changes in rugby league players over 6 years and, demonstrated the individuality of changes [7]. However, interpretation of findings is limited due to the small sample size (n= 12) and absence of analysis based on positions [1]. It is also not clear if the findings can be generalised to rugby union, as there are different demands between the two rugby codes.

Since 1955, the average rugby players’ body mass has increased by approximately 25%, from 85 to 105kg [8]. It remains unknown if players may reach a point where increasing mass is not a consequence of lean mass (LM) but rather body fat [9, 10]. Research supports that lower skinfolds are associated with greater game time [11], and physical performance [12]. Therefore, excess fat mass (FM) is counterproductive to the power-to-weight ratio, as well as acceleration and metabolic efficiency of players [13]. The body composition of players are routinely assessed, predominately to monitor development of physiological capacities (e.g. speed, aerobic fitness) [14], and injury prevention [4, 15]. Direct measurements of body fat percentage (%BF), measured by dual-energy x-ray absorptiometry (DXA); a superior tool for providing accurate and highly detailed body composition assessment in athletic populations [16].

To date, there is a dearth of research investigating longitudinal body composition changes in rugby players, particularly investigating if mass is continuing to increase. Therefore, the aim of this study was to explore 7- year longitudinal DXA data from one professional rugby team to identify body composition trends. Fuller et al, reported that the mean total mass (TM) of players has increased since 2002, and significantly for forwards ($p < 0.01$)[17]. However, to our knowledge, no study has analysed the compositional components responsible for the increased TM. Secondly, we aimed to investigate the longitudinal body composition changes of players with 6 years of DXA scan data. Furthermore, no study has compared body composition profiles of players within the same club, based on their international playing status. This study also aimed to explore body composition based on playing status and during the transition from academy to senior rugby. A secondary aim was to explore %BF classification, derived from DXA.

Materials and methods

Study design

The study assessed 7- year longitudinal changes in TM, LM, FM and %BF in professional rugby players from one club between 2012 and 2019. Players were scanned at 4 time-points each season; baseline, pre-season, mid-season and post-season (Figure 1).

Insert Figure 1

Participants

A total of 123 professional male rugby players from one European Rugby Championship Cup team received DXA scans over 7 years. DXA scan data was available for 21 players for 6 of the 7 consecutive years. Players were grouped by position. Forwards included props, hookers, locks, back. Backs included centres, scrum-halves, fly-halves, wingers and fullbacks. The number of players each season ranged from 19 to 63, with an even distribution between positions (Table 1).

Sub-group analyses of senior international players (any senior club player playing international rugby between 2015-2019) and non-international players (any senior club player not playing international rugby between 2015-2019). Further sub-group analysis of academy players aged 17-20 years (any player playing academy rugby prior to transition to senior rugby), by playing position was included. Academy players' DXA scans were analysed using the same time point for each player during their first 3- years as a senior rugby player. Players diet were controlled by the lead nutritionist, specific to positional demands and training days; aerobic, resistance and rest. This study was conducted in accordance with ethical standards in sport and exercise science research [18]. Ethical approval was provided by the Institution Research Ethics Committee. Additional approval was obtained to access pseudo-anonymised data from the host club for the time period of the study.

Body composition scan acquisition and analysis

All players on the roster between 2012 and 2019 received total body DXA (EnCore version 15.0, GE Lunar Healthcare, Madison, WI) scans across the season. Standardised scanning protocols were followed to ensure consistency in scan acquisition [16]. All scans were conducted by a skilled technologist and analysed following the manufacturer's guidelines

[19]. Athletes were scanned early in the morning (7:00 - 9:00 am), prior to food or fluid ingestion, in a euhydrated state with void bladder, and wearing minimal clothing. Height (cm) and weight (kg) were measured prior to scans. Athletes lay in a supine position on the DXA scanner bed and were positioned with hands in a fully pronated position with an approximate 5cm gap between hands and thigh and the use of GE positioning straps at lower leg to support consistent positioning. The mode used was automatically selected by the software and was dependent on body thickness (standard mode ≤ 25cm; thick mode: > 25cm). Athletes were instructed to remain in position until otherwise instructed. Scans were analysed using GE Lunar Encore software (Version 15.0) and were overseen by a clinical densitometrist certified by the International Society of Clinical Densitometry. The DXA system was serviced annually by the manufacturer and a daily calibration protocol provided quality assurance. No significant drift in calibration was reported during the study time points. No deviation or software upgrades were reported.

The outcomes of interest derived from the DXA scan were to compare %BF values across the 7- years according to values published for male athletes (Gallagher et al., 2000) using DXA scans: low (<8.0%), normal (8.0–19.9%), above normal (20.0–24.9%), and high (≥25.0%) [20, 21]. Body mass index (BMI) was calculated as $kg.m^2$.

Statistical analysis

All analyses were carried out using 'R' version 3.6.1 (R Foundation for Statistical Computing, Vienna, Austria) [22]. Descriptive statistics were calculated as mean [standard deviation (SD)]. Data was found to be normally distributed. Standard linear models were used with normality assumption to determine body composition differences for TM, LM, FM and %BF by playing position; forwards v backs, international v non-international players and academy v senior players. The Mann Kendall Trend tests were used to analyse data over 7 years (2012/13 – 2018/19) for consistently increasing or decreasing trends (monotonic) in y-values using baseline and post-season time points. Out of the full cohort, there were 21 players for whom a full, uninterrupted longitudinal data set (over 6 years) was available. This data set was analysed separately using repeated measures ANOVA. Using post-season scans, players were grouped by %BF classification [20, 21]. Distribution of %BF classifications were analysed for all players and by position, international vs non-international and, academy vs non-academy. A two-sample Kolmogorov Smirnov test was used to identify a significant difference in distribution of %BF classification. Comparison of body composition classification were determined using data from players last recorded scan. Changes to academy players' body composition during the first 3 years of senior rugby were assessed using data from the same time point for each player's first 3 seasons. Scan one was compared to scan two and scan one was compared to scan three to investigate significant changes. Significant differences are represented by $p < 0.05$.

Results

Table 1 presents the mean (SD) for TM, LM and %BF for baseline scans between 2012 and 2019. There were no significant changes in TM, LM or %BF for each year. Over the 7 years, TM increased from 101.6 to 102.4kg with a reduction in variability (SD), LM increased from 80.1 to 81.9kg and, %BF decreased from 17.1 to 15.9%. The mean (SD) TM for players at baseline were: year 1: 101.6kg (13.5), year 2: 102.3kg (12.7), year 3: 101.9kg (11.9), year 4: 102kg (12.7), year 5: 103kg (12.6), year 6: 101.3kg (12.6) and, year 7: 102.4kg (11.4).

Forwards demonstrated no significant change in TM, LM or %BF between the 7 years. Backs demonstrated no significant change in TM, LM or %BF across the 7 years. Forwards had significantly greater TM, LM and %BF than backs for each of the 7 years ($p < 0.05$).

Insert Table 1

Using baseline and post-season data, no significant increase or decrease trends were found for TM, LM or %BF for the team or by position between years ($p > 0.05$) (Table 2).

Insert Table 2

DXA scans were performed on 21 players from 6 consecutive years. In this sub-group there was a significant change in TM for all players over 6 years [$F (5, 100) = 32.4$, $p < 0.00$]. Significant differences in TM were identified between year 1 and 2 ($p < 0.01$), year 1 and year 3 ($p < 0.01$), year 1 and year 4 ($p < 0.01$) and year 3 and year 6 ($p < 0.05$). There was no significant difference found for %BF, LM or FM. By position, forwards had significantly greater mean TM, %BF, LM and FM for each of the 6 years. Forwards ($n = 14$) had a significant change in TM [$F (5, 65) = 4.50$, $p < 0.01$], but no significant change in %BF, FM or LM. Backs ($n = 7$) had no significant change in TM, %BF, LM or FM. No significant differences in means for TM, %BF, LM or FM were identified.

Table 3 presents the %BF classification of players using post season scans for each year, by position. There was a significant difference in the distribution of %BF classification between forwards and backs across all 7 seasons ($p< 0.05$). A greater proportion of forwards were categorised as having excess fat (above normal: 20-24.9% and high: >25%) compared to backs for each year. In the 2018/19 season, no player had %BF in the high category, although 6 forwards categorised as having %BF above normal. One back in 2018 and 2019 had a %BF value <8%. Backs were predominately categorised as normal (8-19.9%) and forwards were predominately categorised as normal (8-19.9%) or above normal (20-24.9%).

Insert Table 3

Thirty-four academy players with complete data from their first 3 seasons of exposure to senior rugby were analysed. There were no significant changes in body composition between first and second DXA scans or between first and third DXA scans ($p> 0.05$) (Table 4). During the first 3 years of senior rugby, academy players demonstrated non-significant increases in TM and LM and reduction in FM and %BF. Sub-group analysis of academy players by position, showed comparable body composition changes.

Insert Table 4

Table 5 presents the mean differences (SD) of players based on their professional status; international players or non-international players over 4 years (2015-19). The number of backs and forwards between groups was evenly distributed for each year. International players between 2015 and 2019 had significantly greater LM (mean difference: 3.3 - 6.3kg) and significantly lower %BF (mean difference: 2.3 - 3.2%) than non-international players for all 4 years ($p < 0.05$). International forwards had a significantly lower %BF than non-international forwards for all 4 years ($p < 0.05$). Differences in %BF between international and non-international backs was not significantly different for all 4 years (Table 5).

Insert Table 5

Discussion

We report that TM increased modestly in rugby players monitored over 7 years, reflecting a longitudinal increase in LM and reduction in %BF, most notably in forwards. At all-time points, forwards had a significantly greater TM, LM and %BF compared to backs ($p < 0.05$). Cross-sectional analysis of all players over each individual season showed forwards consistently had greater reduction in %BF, whereas backs had a greater increase in TM. In the sub-group analysis of academy players transition to senior rugby, academy players demonstrated increases in TM, LM and a decrease in %BF, although not significant. International players had a more favourable body composition. These findings enable greater understanding of changes to players body composition over time and at different stages in their career.

A key finding includes that despite no significant difference, the modest increase in TM between the 7 years was reflected by an increase in LM and decrease in %BF. The average mid-season body mass for forwards was 111.1 ± 7.8kg and backs was 94.8 ± 9kg, in the 2018-19 season. The average body mass for forwards during the 2019 World cup was 114kg; the lightest forward weighing 80kg and the heaviest weighing 153kg [23]. Despite reports of an international trend of substantial increase in average body mass of rugby players [17, 24], data from our cohort does not support this. Although it is plausible that increases in body mass occurred before 2012 in this cohort. Furthermore, it has been suggested that increases in TM is possibly related to changes in injury severity seen in rugby since 2002 [25].

Our finding that rugby forwards have greater %BF than backs is consistent with previous research [1, 2, 6, 26]. Using data from 2018-19, forwards in this study had higher levels of %BF compared to findings reported in previous studies [1, 5, 6, 27]. The negative health consequences of elevated %BF are well documented [28, 29]. FM acts as ballast in biomechanical terms, but adipose tissue is a vital endocrine organ for general health [30]. There remain several rugby forwards with %BF above desired healthy ranges. Rugby forwards are taller and heavier as they are predominately engaged in static play; scrummaging and rucking [31-34]. The higher %BF in forwards may provide protective effects against injuries due to the higher frequency of tackles and contact [26, 35]. However, this has not been found to be consistent and therefore, do not outweigh the potential long-term cardiometabolic risks associated with elevated %BF [36, 37].

Sub-group analysis of 21 players (forwards: 14; backs: 7) with 6 consecutive years of data indicated a significant increase in TM for all players and forwards, however no significant change in %BF, LM or FM. It has been well reported that increasing mass through LM is more beneficial to performance and health than FM [35]. Increased %BF has been shown to have a negative relationship with performance [38], and potentially lead to increased injury risk [39, 40].

Our findings indicate non-significant increases in TM and LM and concomitant decreases in FM during the first 3 years of senior rugby. Body composition changes of academy players is comparable for forwards and backs. Possible justifications for body composition changes, include growth, maturation [41, 42], and exposure to a professional training environment [43]. Till et al reported significant differences in anthropometrics of academy players over 4 years, and significant positional differences [43]. The lack of significant changes in our cohort is possibly due to the average age of first scans was 17 years, where the most significant changes have been reported between 16-17 years [42, 43]. Academy forwards had a significantly greater TM, LM and, %BF compared to backs. When compared to Till et al., (2016), our cohort have greater TM and lower %BF [27]. Compared to senior players, academy players have a greater %BF, despite having a lower TM and LM. Academy players are likely to still be in the natural growing years [41, 42]; therefore, monitoring of body composition should be regarded as an important component of player monitoring [44].

Despite similar distribution of players per playing position; backs and forwards, international rugby players were found to have significantly lower %BF and greater LM compared to non-international players at all time points over 4 years (2015-19). To our knowledge, this is the first study to investigate the difference in body composition between international and non-international players from the same club. International players represent a subgroup of rugby players who are performing at the highest level of selection achievable. Characterisation of this population in comparison to those who did not achieve this level of selection is useful for practitioners and future players aspiring to reach this playing status.

This difference in body composition may represent a genetic factor or independent training component. All players within this study are from the same club and thus exposed to the same training and nutritional programs. Thus, within the context of this study, it is not possible to quantify the cause.

While the current study addresses multiple gaps in the literature, some limitations exist. When assessing trends, baseline and post-season time points were used due to having the least amount of missing data. Furthermore, findings are reflective of body composition trends within one professional rugby club and is not representative of individual changes. Despite classifying players by position, a larger sample size would allow for further classification [33]. Generalisation of longitudinal findings are limited due to a small sample size (n= 21) with 6 consecutive seasons of DXA data. Sub-group analysis of academy players and international players have small number of participants; therefore, limiting the generalisability of findings. Goals pertaining to body composition changes can be highly specific to individual athletes. Although it is not possible to account for individual goals and baseline body mass, data is presented to reflect changes specific to position, playing status and, academy players. Finally, no formal hydration tests were performed.

Conclusions

Although no significant body composition trends, irrespective of position were apparent for rugby players over 7 years, findings from this study provides useful information for practitioners supporting the physical conditioning of rugby players. Although the sample size analysing longitudinal changes is small, findings provide some insight into an area previously unanswered. Rugby practitioners need to consider the cost benefit of increasing player’s mass for performance benefits and the potential long-term health risks associated with elevated mass. Although mass is an integral component to performance, players with increased mass were found to have a greater propensity to have %BF above desired healthy ranges. This is particularly prudent to academy and non-international players who have comparable TM to senior and international players but significantly different compositional profiles. Differences between academy and senior players are expected. Findings from this study provide insight into the longitudinal changes of academy players body composition. Rugby practitioners need to be conscious of these differences and use a longitudinal approach to data measurement to assess player development.

Figure legends

Figure 1: Timeline of DXA scan assessments within each season.

Table 1: Baseline body composition values for 7- years; from 2012 to 2019.

Table 2: Trend analysis for changes in body composition from 2012/13 to 2018/19 season.

Table 3: Classification of body fat percentage classification by playing position.

Table 4: Body composition of players during transition from academy to professional rugby.

Table 5: Body composition comparison between International players and non-international players.

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