# Lean Mass, Muscle Strength, and Muscle Quality in Retired Rugby Players: The UK Rugby Health Project

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**ABSTRACT**

Although athletes from sports such as rugby have greater lean mass and strength during their playing careers, little is known about these characteristics post-retirement. Therefore, this study investigated lean mass, strength, and muscle quality in retired elite and amateur rugby players and non-contact athletes. Retired elite male rugby players (n = 42, 43.9 ± 10.3 y; 101.1 ± 13.4 kg; 1.82 ± 0.09 m), amateur rugby players (n = 46, 48.0 ± 10.5 y; 98.9 ± 16.6 kg; 1.79 ± 0.07 m) and non-contact athletes (n = 30, 51.3 ± 12.5 y; 91.3 ± 13.4 kg; 1.79 ± 0.07 m) received one total body dual-energy X-ray absorptiometry assessment of appendicular lean mass (ALM) and ALM index (ALMI). Grip strength was measured, and muscle quality (grip strength/unit of arm lean mass) was calculated. Sarcopenia was identified as ALMI < 7.23 kg/m$^2$ and handgrip strength < 37.2 kg. Total lean mass, ALM and grip strength were greater in the elite rugby compared to amateur rugby and non-contact groups ($p < 0.01$). There were no significant differences in muscle quality or sarcopenia prevalence. Retired elite rugby players had greater lean mass and grip strength than amateur rugby and non-contact athletes, although muscle quality was similar. The greater lean mass and strength might reflect genetic influences or previous participation in a highly physical sport.

## Introduction

Physical activity and exercise promote the accumulation of lean mass, which is important for reducing the risk of sarcopenia [1]. Competitive athletes engage in high levels of exercise throughout their sporting careers, and this is reflected in their unique physique and body composition [2, 3]. Rugby players have demonstrated greater body mass and lean mass [4] as well as muscle strength [5] compared to non-athletes of the same age. The assumed performance advantage gained from greater stature and mass means that this is a differentiating characteristic of rugby players at the elite level [6] as well as higher lean and lower fat mass compartments [6, 7]. The contact nature of rugby places importance on the ability to generate momentum, thus making speed and mass distinguishing characteristics of successful players [8].

Lean mass and strength accumulate from birth until adulthood, but from around midlife there is a progressive loss of lean mass

[9, 10]. Sarcopenia is the term originally proposed to describe this age-associated loss of muscle mass [11], developing later to encompass the loss of strength [12]. The most recent working definition has since incorporated additional measures, including muscle quality and physical performance [10]. Importantly, the loss of strength with age is more pronounced and occurs earlier than the loss of muscle mass [13]. Sarcopenia is an important area of focus given its association with several undesirable outcomes such as an increased risk of falls, prolonged hospital stays, morbidity, and mortality [14]. In particular, muscle strength rather than mass is associated with mortality in later life [15]. In a study by Ruiz et al. (2008), older males grouped in the lowest third for strength had a mortality rate 50 % greater than those in the upper third [16, 17]. Therefore, the maintenance of lean mass and muscle strength with age are important goals for supporting longevity and functional capacity.

The variation in muscle mass and strength between individuals is a multifactorial issue explained by both the attainment of peak mass and strength in young adulthood and the rate of muscle loss thereafter [18]. While there is loss of muscle mass and strength over time, the loss of mass alone does not fully explain the loss of strength, given that where mass has been maintained, strength has still declined [13].

Muscle quality, as measured by the amount of force per unit mass (kg/kg) [19], is a complementary tool for musculoskeletal health and sarcopenia assessment [20, 21]. Given that strength deteriorates more rapidly that lean mass [22], muscle quality has been shown to decrease with advancing age [23]. Although cut-points for muscle quality of < 5.76 kg/kg for men have been developed [24], robust and specific thresholds for older populations remain to be determined.

While it is established that athletes from sports such as rugby have superior lean mass and strength during their playing careers, little is known about these qualities post-retirement. Therefore, the purpose of this study was to investigate the impact of previous participation in rugby codes by comparing lean mass, muscle strength, and muscle quality in former competitive rugby players and non-rugby players.

# Methods

This study comprised a cross-sectional analysis of 139 participants from the UK Rugby Health Project. With a multidisciplinary research focus, the UK Rugby Health Project was initiated in 2016 and has been described elsewhere [25]. The primary outcome variables for this current study were lean mass, muscle strength, and quality. The project was approved by the University Research Ethics Committees and informed consent was obtained from all participants.

## Participants

Participants were recruited using past player/athlete associations, printed and televised media outlets, word of mouth, and social media between September 2016 and December 2018. Upon completion of a general health questionnaire (GHQ), participants were invited to attend an appointment at the University for clinical testing, including body composition and strength assessment. A total of 254 participants completed the GHQ and 108 retired athletes attended for clinical testing. Retired rugby players (n = 88) had previously competed in rugby union, rugby sevens, or rugby league for at least three years and included 42 former elite and 46 amateur rugby players. The non-contact group (n = 30) consisted of retired non-contact athletes, predominantly (n = 24) retired cricket players. Participant characteristics are reported in ▶ **Table 1**.

## Procedures

Participants were asked to arrive at the laboratory in a fasted and hydrated state and abstain from alcohol, intensive exercise, and caffeine for the previous 12 hours. Following a brief schedule of events, participants completed an adapted screening questionnaire and received basic anthropometry. Wearing only light, loose clothing, height was assessed using a stadiometer (SECA Alpha, Birmingham, UK) and body weight was measured using calibrated electronic scales (SECA Alpha 770). Blood pressure was measured as part of the screening procedure. Participants were excluded from strength testing if they had a history of cardiovascular disease, high blood pressure (> 140/90 mmHg) or a relevant injury to the upper limb (n = 35). Following exclusion of participants who failed the screening process, there were 31 elite rugby, 28 amateur rugby, and 24 non-contact group participants for strength and muscle quality measures.

### Body composition

Each participant received one total-body dual-energy X-ray absorptiometry (DXA) scan (GE Lunar iDXA; GE Healthcare, Madison, WI, USA). Daily quality assurance tests were performed on testing days and all scans were performed by a registered radiographer or certified densitometrist. Participants were scanned in the supine position, with arms placed close to the sides, hands mid-prone, and legs immobilised in position using the provided ankle strap. In 21 cases where the arm of

▶ **Table 1** Participant demographics for retired rugby code and non-rugby participants, presented as mean ± standard deviation.

| | | Age (y) * | Body mass (kg) | Height (m) | Body mass index (kg/m²) * |
|---|---|---|---|---|---|
| **Elite Rugby, n = 42** | | 43.9 ± 10.3 | 101.1 ± 13.4 | 1.82 ± 0.09 | 30.7 ± 3.8 |
| **Amateur Rugby, n = 46** | | 48.0 ± 10.5 | 98.9 ± 16.6 | 1.79 ± 0.07 | 30.7 ± 4.5 |
| **Non-contact, n = 30** | | 51.3 ± 12.5 | 91.3 ± 13.4 | 1.79 ± 0.07 | 28.6 ± 3.8 |
| **Difference, *P*** | **Elite vs. Amateur** | 0.117 | 1.000 | 0.493 | 1.000 |
| | **Elite vs. Non-contact** | 0.019 | 0.018 | 0.303 | 0.050 |
| | **Amateur vs. Non-contact** | 1.000 | 0.088 | 1.000 | 0.074 |
| **Cohen's *d*** | **Elite vs. Amateur** | 0.39 | 0.15 | 0.29 | – |
| | **Elite vs. Non-contact** | 0.66 | 0.73 | 0.38 | 0.55 |
| | **Amateur vs. Non-contact** | 0.29 | 0.49 | 0.11 | 0.49 |

* Data not normally distributed.

▶ **Table 2** Body composition, muscle strength, and muscle quality in retired rugby code and non-rugby participants, presented as mean ± standard deviation.

| | Elite Rugby | Amateur Rugby | Non-c ontact | *P* | | | Cohen's *d* | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Elite vs. Amateur | Elite vs. Non-contact | Amateur vs. Non-contact | Elite vs. Amateur | Elite vs. Non-contact | Amateur vs. Non-contact |
| Total lean mass (kg) | 71.6 ± 9.5 | 65.2 ± 7.6 | 60.0 ± 7.8 | 0.002 | < 0.001 | 0.027 | 0.74 | 1.31 | 0.68 |
| Appendicular lean mass (kg) | 34.6 ± 5.1 | 30.9 ± 4.1 | 28.3 ± 4.2 | < 0.001 | < 0.001 | 0.051 | 0.81 | 1.33 | 0.62 |
| Arms lean mass (kg) | 9.7 ± 1.7 | 8.4 ± 1.1 | 7.5 ± 1.3 | < 0.001 | < 0.001 | 0.031 | 1.00 | 1.47 | 0.72 |
| Legs lean mass (kg) | 24.9 ± 3.6 | 22.5 ± 3.2 | 20.8 ± 3.0 | 0.003 | < 0.001 | 0.086 | 0.70 | 1.22 | 0.55 |
| Lean mass index (kg/m$^2$) | 21.6 ± 2.0 | 20.2 ± 1.7 | 18.7 ± 1.7 | 0.001 | < 0.001 | 0.002 | 0.76 | 1.53 | 0.86 |
| Appendicular lean mass index (kg/m$^2$) | 10.5 ± 1.1 | 9.6 ± 0.9 | 8.8 ± 1.0 | < 0.001 | < 0.001 | 0.009 | 0.87 | 1.51 | 0.77 |
| Body fat percentage (%) | 25.8 ± 6.3 | 30.6 ± 6.6 | 31.1 ± 7.0 | 0.003 | 0.003 | 1.000 | 0.74 | 0.80 | 0.08 |
| Muscle quality (kg/kg) | 5.57 ± 0.86 | 5.92 ± 0.86 | 5.93 ± 0.96 | 0.428 | 0.438 | 1.000 | 0.40 | 0.39 | 0.01 |
| Grip strength (kg) | 54.3 ± 8.9 | 48.8 ± 8.0 | 45.5 ± 7.3 | 0.038 | < 0.001 | 0.435 | 0.64 | 1.07 | 0.43 |

the participant did not fit within the scan area, the contralateral arm data was replicated. Three-component (bone mineral content, lean tissue mass and fat mass) total body composition data were acquired. Regional composition data were also derived, allowing for the calculation of appendicular lean mass (ALM; total lean mass of the arms and legs) and muscle quality as the amount of force per unit mass [24]. In vivo precision for total body composition in adults for the DXA used in the current study is 0.51 % for total body lean tissue mass, 0.82 % for total body fat mass and 0.86 % for percentage total body fat [26].

### Strength assessment

Handgrip strength was assessed in 59 rugby and 24 non-rugby participants using a Takei T.K.K. 5401 handgrip dynamometer (Takei Scientific Instruments Co., Ltd, Niigata, Japan). Both hands were tested in an upright standing position, with the arm positioned straight by the side, with the shoulder slightly abducted and feet approximately shoulder width apart [27]. The participant was asked to breathe in and squeeze the dynamometer as they breathed out. Each hand was tested three times, alternately, ensuring a one-minute interval between each attempt on the same hand. The maximum effort recorded from the six attempts is presented. Muscle quality was calculated as grip strength relative to upper body ALM/arm lean mass (kg/kg).

### Sarcopenia assessment

In the absence of a single consensus, there are several measures recommended to classify an individual as sarcopenic, with several recommended cut-points [14]. The European Working Group on Sarcopenia in Older People (EWGSOP) [10] recommends several cut-points for the identification of sarcopenia, based on European populations. These include, for men, grip strength of < 27 kg [9], ALM of < 20 kg [28] and appendicular lean mass index (ALMI; ALM/height$^2$) of < 7.0 kg/m$^2$ [29]. Alternatively, higher cut-points have been employed in other studies, such as < 37.2 kg for grip strength [24] and ALMI of < 7.23 kg/m$^2$ [30]. We assessed the presence of sarcopenia in each group using these higher cut-points to compare prevalence among each group.

## Statistical analyses

Statistical analyses were performed with IBM SPSS Statistics (Version 26; IBM Corp., Armonk, NY, USA). Normality was assessed visually and using Kolmogorov – Smirnov tests. Between-group differences, where distributions were normal, were assessed using one way analysis of variance (ANOVA). For distributions where normality could not be assumed, non-parametric Kruskal – Wallis tests were performed. Post-hoc tests were performed and significance values adjusted by the Bonferroni correction for multiple tests. All data are reported as mean ± standard deviation (SD). Fisher's exact test was used to determine the significance of differences between proportions of those categorised as sarcopenic. Cohen's d effect size calculations were performed using the R programming language (Version 4.0.3) and classified using the following thresholds: < 0.2 = trivial; 0.2–0.5 = small; 0.5–0.8 = moderate, and > 0.8 = large [31].

# Results

The body composition and strength outcomes for the retired elite and amateur rugby and non-contact groups are presented in ▶ **Table 2**.

▶ **Table 3** Sarcopenia prevalence according to the designated assessment tool in retired rugby code and non-rugby participants.

| Sarcopenia criteria | Elite Rugby | Amateur Rugby | Non-contact | *P* |
|---|---|---|---|---|
| Grip strength < 27 kg [9] | 0 % | 0 % | 0 % | – |
| Appendicular lean mass (ALM) < 20 kg [28] | 0 % | 0 % | 3.3 % | 0.244 |
| ALM/height$^2$ < 7.0 kg/m$^2$ [29] | 0 % | 0 % | 0 % | – |
| Grip strength < 37.2 kg [24] | 3.2 % | 3.6 % | 12.5 % | 0.434 |
| ALM/height$^2$ < 7.23 kg/m$^2$ [38] | 0 % | 0 % | 0 % | – |
| Muscle quality < 5.76 kg/kg [24] | 64.5 % | 46.4 % | 45.8 % | 0.282 |

### Body composition

The elite rugby group had significantly higher appendicular lean mass compared to amateur rugby and non-contact groups ($p < 0.001$, Cohen's $d > 0.8$).

### Strength and muscle quality

Grip strength was greater in the retired elite rugby group compared to the non-contact group ($p < 0.001$, constituting a large effect) and the community rugby group ($p = 0.038$). There were no significant differences in muscle quality between the amateur rugby group and the non-contact group (small effect). No significant differences in muscle quality were seen across the groups. However, muscle quality was lower in the elite rugby group compared to the amateur rugby and non-rugby groups (small effect).

### Prevalence of sarcopenia

No significant differences were seen in sarcopenia prevalence among the three groups. In the non-contact group, 12.5 % (n = 3) were below the 37.2 kg threshold for grip strength [24] compared to 3.2 % (n = 1) in the elite rugby group and 3.6 % (n = 1) in the amateur rugby group ($p = 0.434$). Prevalence was highest using the < 5.76 kg/kg threshold for upper body muscle quality [24]. In the elite rugby group 64.5 % (n = 20) were below the cut-off compared to 46.4 % (n = 13) and 45.8 % (n = 11) in the amateur rugby and non-contact groups respectively. Sarcopenia prevalence is presented in ▶ **Table 3**.

## Discussion

This study investigated lean mass, strength, and muscle quality in retired elite male rugby players compared to an age- and sex-matched amateur rugby group and a sex-matched non-contact group. In doing so, the significant findings were, firstly, that while retired elite rugby players had greater overall lean mass and strength, compared to both groups there were no differences in muscle quality between groups. Secondly, there were no differences in strength between the amateur rugby group and non-contact group. Thirdly, the prevalence of sarcopenia was low in all three groups when using most sarcopenia cut-points, except for muscle quality [24]. A further observation was of a lower body fat percentage in elite compared to the amateur rugby group and non-rugby group. There were no differences in body fat percentage between the amateur rugby and non-rugby groups.

The elite rugby group had greater lean mass and strength compared to retired amateur rugby players and non-contact athletes. Higher body mass has been observed in currently active elite rugby union and rugby league players compared with non-athletes [4] and this was present in retirement with a significantly higher BMI in former elite rugby players ($p = 0.050$, moderate effect), corroborating the findings of Hind and colleagues [4]. Conversely, former elite college athletes performed worse than controls in several measures, including body composition and strength, with the authors suggesting a limited ability to perform physically due to previous injury as an explanation for such outcomes [32]. It might be plausible that the high injury toll in rugby and two-fold increased prevalence of osteoarthritis in retired players [25] may limit the ability of a former player to remain active. However, in the current study, higher levels of lean mass and significantly higher grip strength were seen in former elite rugby players.

When comparing the values to those from currently competitive professional rugby players in the UK, the retired elite rugby code players had greater body mass (101.1 vs. 96.5 kg) but less lean mass (71.6 vs. 74.6 kg), arm lean mass (9.7 vs. 10.0 kg) and leg lean mass (24.9 vs. 25.3 kg) [33]. Notwithstanding, the volume of lean mass, the lean mass index and the ALMI of the retired rugby players were all higher than mean values for players aged 20–29 years in published reference data [34]. Moreover, the elite rugby group placed in the 80$^{th}$ percentile of the 40–49 yr age group for measures of lean mass and ALMI [34]. Taken together, these findings suggest that retired rugby players may experience lasting benefits for body composition long after their careers have concluded.

No significant difference in muscle quality between the rugby and non-rugby groups was seen in the current study. However, it is noteworthy that the elite rugby group had the lowest recorded muscle quality compared to both amateur rugby and non-contact athletes (small effect). Previous studies have demonstrated an inverse relationship between muscle mass and muscle quality [35] with higher levels of upper limb lean mass associated with lower muscle quality and lower muscle quality associated with functional impairments [35]. This is consistent with the findings from the current study, given that retired elite rugby players have higher levels of lean mass and strength but lower muscle quality. It may be possible that there has been a loss of strength since peak at a greater rate than loss of mass. However, the cross-sectional design of the current study only allows for speculation, although strength is known to decrease at a greater rate than mass [35]. Given that the rugby group demonstrated higher levels of lean mass and ALMI, this would yield functional benefit of higher levels of muscle with similar quality.

We found no differences in body fat percentage between the retired amateur rugby and non-contact group, although lower levels of body fat were seen in the elite rugby group compared to both groups (p = 0.003, moderate effect). Higher BMI in rugby players has previously been seen with comparable levels of body fat [4] and this should also be considered in retirement given the risk for cardiometabolic disease [36]. Furthermore, in other studies of former endurance athletes, lower body fat percentage was found compared to controls [37]. Both rugby groups had higher BMI at 30.7 kg/m$^2$, largely as a result of higher levels of lean mass. It should be noted that BMI is employed as a measure of cardiometabolic health but is somewhat limited by an inability to differentiate lean mass from fat mass. The rugby groups would be classified as obese on this basis, a potentially misleading conclusion given the benefits of higher levels of lean mass with advancing age.

Members of the elite rugby group were heavier and had greater lean mass and grip strength compared to non-contact controls, with no significant differences in muscle quality. Furthermore, the prevalence of sarcopenia was not significantly different across the groups. The low prevalence of sarcopenia in the rugby and non-contact athletes suggests there may be a beneficial effect of rugby participation in youth and young adulthood for muscle health in ageing. However, all groups had much higher prevalence of sarcopenia when muscle quality was the chosen measure (64.5 % elite; 46.4 % amateur; 45.8 % non-contact). Given that levels of lean mass would have likely been superior during young adulthood, a dramatic loss of mass seems unlikely. However, the performance advantage gained from possessing higher body mass makes those with a genetic advantage in this area likely to be identified as such, and thus attain success in the sport. The significance and practical impact of lower muscle quality (small effect) in the elite rugby group compared to both the community and non-rugby groups warrant additional exploration, given the superior strength of the rugby group. Moreover, further work is needed to determine the relevance of muscle quality as a measure of sarcopenia in the absence of low grip strength.

There were several considerations to make when interpreting the results of this study. First, the study design was cross-sectional and therefore cause and effect inferences could not be made. Secondly, participants self-selected and the impact of the potential genetic predisposition to superior muscle mass and strength of those who participated in rugby limited the conclusions to be drawn from such a study. Thirdly, the median age of this cohort was 47 years and relatively early in the ageing process, and thus did not allow for inferences to be made for the older ageing population. Moreover, sarcopenia cut-points [24] were developed in older adults over 60 years. Fourthly, the lack of exercise and diet data restricted the investigation of the impact of such factors. Therefore, future studies focussed on exercise and diet habits in an older retired population would be valuable.

In conclusion, the retired elite and community rugby players had higher lean mass and superior grip strength compared to their non-rugby counterparts. However, no significant difference was seen in muscle quality. The aim of efforts to reduce sarcopenia focus on preventing the loss of lean tissue from peak levels attained in adulthood. The potential benefits of previous rugby participation on muscle mass and strength appear to be retained somewhat and this is relevant given the positive functional implications for activities of daily living. Future research with a focus on the longitudinal assessment of muscle quality, diet, and exercise in rugby players post retirement would be valuable.

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### Conflict of Interest

The authors declare that they have no conflict of interest.

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