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Correlation Between Body Composition and VO_2max Among Male and Female University Rugby 7 Athletes

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***Abstract* – This study aimed to examine the correlation between body composition and VO_2max among male and female university Rugby 7 athletes. Given the physiological demands of Rugby 7s, understanding how structural attributes relate to aerobic capacity may provide valuable insight for athlete development and performance optimization. Participants consisted of officially registered male and female Rugby 7 athletes from Universiti Putra Malaysia, selected based on their inclusion in the Malaysian University Games (MASUM) squad. Body composition parameters—including muscle mass, fat-free mass, body fat percentage, BMI, and basal metabolic rate—were measured using the InBody 230 bioelectrical impedance analyzer. VO_2max was assessed using the Bruce treadmill protocol and analyzed via the COSMED Quark CPET gas analyzer. Pearson correlation analyses were conducted to explore the relationships between VO_2max and body composition metrics. Male athletes exhibited higher values in most parameters as expected, including VO_2max, muscle mass, fat-free mass, and basal metabolic rate, while female athletes demonstrated higher body fat percentage. Correlation analyses showed negative trends between VO_2max and BMI, body fat percentage, and muscle mass, particularly among females; however, none of these relationships were statistically significant. Although no significant correlations were found, the observed trends suggest that body composition may influence VO_2max in complex and sex-specific ways. These findings highlight the importance of comprehensive, individualized training and assessment strategies that consider both structural and functional components of performance. Future research should include larger samples, positional analysis, and longitudinal designs to further clarify the role of body composition in cardiorespiratory fitness among Rugby 7 athletes.**

***Keywords* – VO_2max, body composition, Rugby 7, muscle mass, fat-free mass, aerobic capacity, university athletes**

I. INTRODUCTION

Rugby Sevens (Rugby 7s) is a variant of rugby union that emphasizes speed, agility, and endurance over short bursts of high-intensity play. Unlike the traditional 15 player format, Rugby 7s fields only seven players per team and is played in much shorter halves, resulting in a more dynamic and physically demanding game. Athletes must exhibit high levels of anaerobic and aerobic conditioning, muscular power, and body control. Consequently, physical attributes such as body composition and cardiorespiratory fitness, particularly maximal oxygen uptake (VO_2max), play vital roles in determining athletic performance in Rugby 7s (Scantlebury et al., 2022; Till et al., 2017; Brazier et al., 2020).

Rugby, by nature, is a sport characterized by a combination of intermittent high-intensity efforts movements such as sprinting, tackling and rucking with frequent changes in direction and position. These diverse demands require players to maintain a high level of muscular strength, agility, power, and endurance (Scantlebury et al., 2022; Till et al., 2017). While positional demands differ in rugby union with forwards typically possessing greater muscle mass and strength, and backs requiring greater speed and aerobic endurance, Rugby 7s players often need a hybrid profile. They must be both lean and powerful to navigate the condensed field space and sustain repeated bouts of high-intensity work.

Several studies have highlighted the physiological profiles of elite rugby athletes. Brazier et al. (2020) noted that elite rugby players exhibit distinct anthropometric characteristics, including high fat-free mass and specific positional body mass ranges, which significantly correlate with game performance. These physical traits are typically developed through specialized strength and conditioning programs (Davies et al., 2016; Hamlin et al., 2020).

Body composition is defined by the proportions of fat mass, muscle mass, fat free mass (FFM)and bone mineral content in the body is a fundamental measure in sports science and athletic performance. For competitive athletes, especially those in sports requiring repeated sprints and high work capacity like Rugby 7s, having an optimal ratio of lean mass to fat mass is crucial. Low fat mass is associated with improved movement efficiency and speed, while higher lean mass supports explosive strength and resilience to physical collisions (Campa et al., 2021; Hind et al., 2015).

Moreover, the role of body composition extends beyond performance enhancement. It is also crucial in injury prevention, where higher lean mass can offer better structural support and reduce injury risk (İşler et al., 2025; Summer et al., 2023). Excessive fat mass, conversely, may contribute to decreased agility and increased fatigue, limiting an athlete's ability to recover between high-intensity efforts and increasing injury susceptibility.

Rugby players at elite levels are typically characterized by a balance of low body fat percentages and high muscle mass. This optimized composition supports greater power-to-weight ratios—essential in explosive actions such as tackles, line breaks, and acceleration bursts (Smart et al., 2013; Adnan et al., 2013). Achieving this balance, however, is a multifactors endeavour influenced by training

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regimens, nutritional practices, and recovery strategies (Sanfilippo et al., 2019; Jagim et al., 2021).

VO_2max represents the maximal volume of oxygen an individual can utilize during intense exercise. It is a central metric in sports science for assessing cardiorespiratory fitness and is often used to predict endurance performance. VO_2max is expressed in milliliters of oxygen consumed per kilogram of body weight per minute (ml/kg/min), making it particularly relevant in sports like Rugby 7s, where aerobic capacity is crucial for sustained performance (Wilder et al., 2006; Crowley et al., 2022; Muñoz-Vásquez et al., 2023).

There is a well-established physiological relationship between body composition and VO_2max. Lean body mass supports enhanced oxygen transport and utilization through greater capillary density and mitochondrial content in muscle tissue (Martín-Rodríguez et al., 2024; Crowley et al., 2022). On the other hand, high fat mass contributes little to aerobic energy production and may even impair VO_2max scores due to the added non-functional weight.

In athletic populations, particularly those in weight-sensitive or endurance-demanding sports, relative VO_2max is strongly influenced by body composition. Athletes with similar absolute VO_2max values may exhibit vastly different relative values depending on their fat-free mass and overall body weight (Ramadhan et al., 2022; Crowley et al., 2022). As a result, training interventions that favour lean mass retention or gains, alongside fat mass reduction, can yield substantial improvements in VO_2max and performance.

This relationship underscores the rationale for this study, which seeks to evaluate the correlation between body composition and VO_2max specifically among male and female university Rugby 7 athletes. Understanding this correlation can provide insights into how physical attributes contribute to physiological capacity and inform training decisions tailored to the unique demands of Rugby 7s.

II. METHOD

Participants

Participants for this study were selected from the official male and female Rugby 7 teams of Universiti Putra Malaysia (UPM). These athletes were the confirmed representatives of the university for the Malaysian University Games (MASUM) Championship, indicating they had undergone prior selection and were actively training under the university's sports program. Only players who were officially registered with the UPM Sports Centre and listed on the final squad roster submitted for MASUM were eligible for inclusion in the study. Both male and female players were included to allow for sex-based comparisons in performance and physiological parameters. All selected participants were informed about the study procedures and provided written informed consent before data collection. Inclusion criteria required participants to be free from injury, currently in full training, and available during the data collection period.

VO_2max Analysis

VO_2max was assessed using a graded exercise test following the Bruce treadmill protocol and measured with the COSMED Quark CPET breath-by-breath gas analyzer. Participants were advised to avoid strenuous activity, caffeine, and large meals for at least three hours before testing.

The Bruce protocol involves progressive 3-minute stages with increasing treadmill speed and incline, beginning at 2.7 km/h with a 10% incline, and continued until volitional exhaustion. Expired gases were collected continuously through a facemask connected to the COSMED analyzer.

Body composition analysis

Body composition was measured using the InBody 230 bioelectrical impedance analyzer (Biospace Co., Ltd., Seoul, Korea), a portable device that estimates body fat percentage, fat-free mass, skeletal muscle mass, and total body water. Participants were instructed to follow standard pre-test guidelines, including fasting for at least 2 hours, avoiding exercise, caffeine, and alcohol for 12 hours, and emptying their bladder 30 minutes before testing. All measurements were conducted with participants standing barefoot, wearing light clothing, and having removed any metal accessories.

III. RESULTS

TABLE 1: COMPARISON BETWEEN MALE AND FEMALE VO2MAX AND BODY COMPOSITION

	Male	Female
Age (years)	23.1 ± 2.77	23.36 ± 2.46
Height (cm)	169.1 ± 4.56	159.73 ± 4.63
VO2 max (ml/kg/min)	41.14 ± 5.5	32.46 ± 3.7
Weight (kg)	74.18 ± 9.8	58.27 ± 7.8
Muscle Mass(kg)	34.47 ± 3.1	23.34 ± 2.7
Body Fat Mass (kg)	13.92 ± 6	15.76 3.92
Fat Free Mass(kg)	60.26 ± 5.2	42.51 ± 4.54
BMI (kg/m2)	25.88 ± 2.62	22.78 ± 2.08
PBF (%)	18.18 ± 5.92	26.81 ± 3.47
BMR (kcal)	1672 ± 112	1288 ± 98

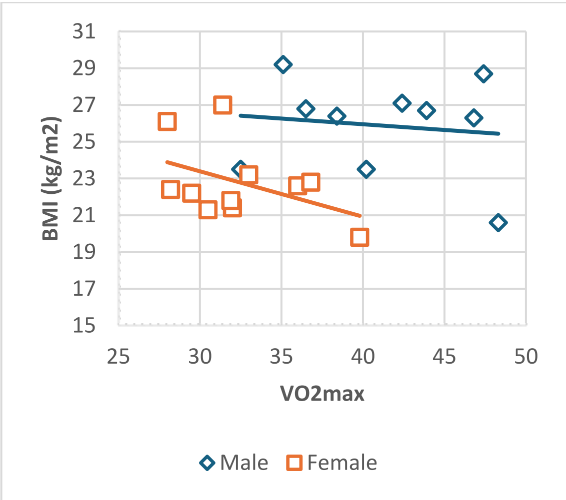

Figure 1: Correlation Between BMI and VO_2max

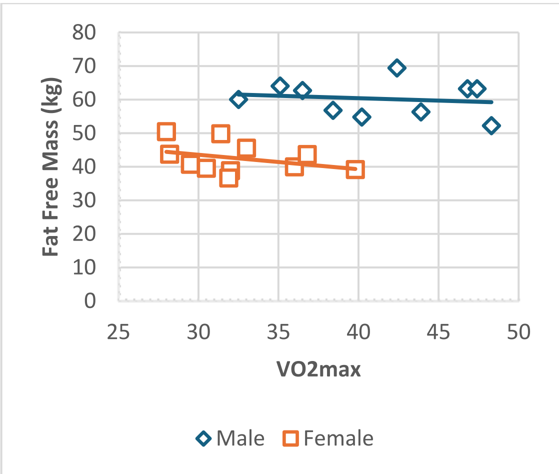

Figure2: Correlation Between Fat Free Mass and VO_2max

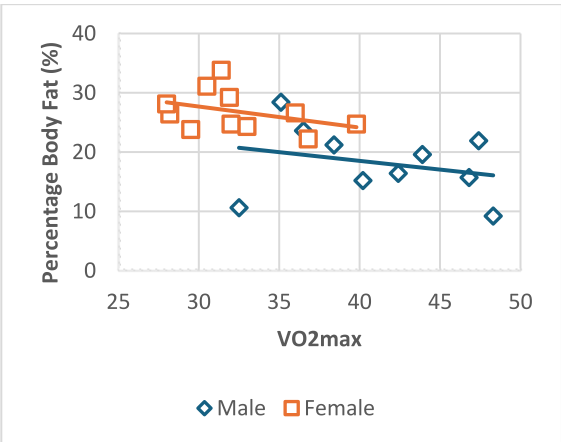

Figure 3: Correlation Between Percentage Body Fat and VO_2max

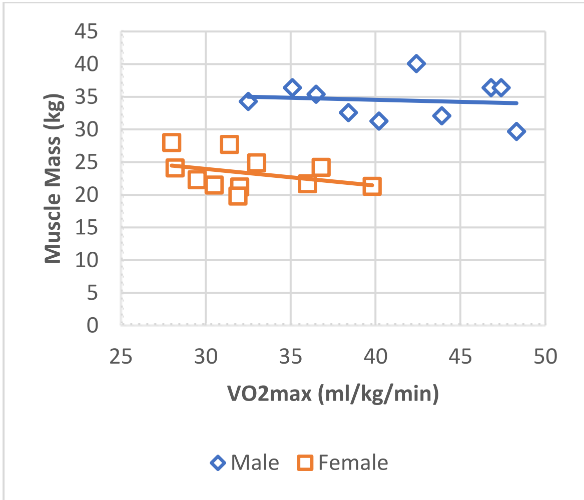

Figure 4: Correlation Between Muscle Mass and VO_2max

Table 1 presents the descriptive statistics for male and female participants. Males showed higher average values across several physiological parameters, including VO_2max (41.14 ± 5.5 ml/kg/min), muscle mass (34.47 ± 3.1 kg), and fat-free mass (60.26 ± 5.2 kg), while females had lower VO_2max (32.46 ± 3.7 ml/kg/min), muscle mass (23.34 ± 2.7 kg), and fat-free mass (42.51 ± 4.54 kg). Percentage body fat (PBF) was notably higher in females (26.81 ± 3.47%) compared to males (18.18 ± 5.92%).

Figure 1 illustrates the relationship between BMI and VO_2max, indicating a mild negative correlation in both males and females. As VO_2max increased, BMI values tended to decrease, especially among female participants.

Figure 2 shows the correlation between fat-free mass (FFM) and VO_2max. Among males, FFM remained relatively stable across different VO_2max levels, whereas females showed a slight decline in FFM with increasing VO_2max.

Figure 3 presents the relationship between percentage body fat (PBF) and VO_2max, displaying a clear inverse trend for both sexes. Individuals with higher VO_2max exhibited lower PBF, with a more pronounced trend among males.

Figure 4 illustrates the association between muscle mass and VO_2max. In males, muscle mass remained relatively constant across varying VO_2max levels, suggesting little to no correlation. However, in females, a slight decrease in muscle mass was observed with increasing VO_2max, indicating a weak negative association.

IV. DISCUSSION

This study aimed to examine the correlation between body composition parameters and VO_2max among male and female university Rugby 7 athletes. Although negative associations between BMI, percentage body fat, and VO_2max were observed, the results revealed that none of the correlations reached statistical significance. Despite this, several meaningful interpretations can still be drawn when contextualized within existing literature and physiological principles.

As expected, male participants demonstrated higher values across most physiological variables, including

VO_2max, muscle mass, fat-free mass, and basal metabolic rate. These findings align with established research highlighting sex-based physiological differences, whereby males typically exhibit greater lean body mass and cardiovascular efficiency, leading to enhanced oxygen delivery and uptake during exercise (Muñoz-Vásquez et al., 2023; Crowley et al., 2022). The observed VO_2max difference between males and females likely reflects such physiological disparities, as males generally have higher hemoglobin concentrations and cardiac output (Wilder et al., 2006; Hall et al., 2021). In addition, females showed higher body fat percentages compared to males, which is consistent with existing anthropometric norms in athletic populations (Campa et al., 2021).

The absence of significant correlations between body composition and VO_2max may be attributed to several factors. First, the relatively small sample size likely limited the statistical power of the analysis. Coupled with intra-group variability in fat mass, lean mass, and VO_2max values, this may have obscured underlying associations. Second, since all participants were Rugby 7 athletes, their training regimes, fitness levels, and physical demands were likely similar, potentially reducing variability in the data. As previously noted by Crowley et al. (2022), individual responses to aerobic conditioning and VO_2max testing are highly variable and shaped by personal training histories, age, sex, and genetic predispositions.

Another possible explanation for the lack of significant findings lies in the complex and multifactorial nature of VO_2max. While body composition is an important component of aerobic performance, it is only one part of a broader physiological system. Factors such as mitochondrial efficiency, stroke volume, pulmonary function, and capillary density also play vital roles in determining VO_2max (Muñoz-Vásquez et al., 2023; Bidhuri et al., 2025). Therefore, the absence of strong statistical correlations with body composition metrics does not necessarily negate their importance but highlights the need for multidimensional performance assessments.

Despite the non-significant findings, the direction of the trends observed remains consistent with theoretical expectations. For example, the inverse relationship between percentage body fat and VO_2max is well-supported in the literature, as fat mass contributes little to aerobic work and represents non-functional weight (Martín-Rodríguez et al., 2024; Jagiełło et al., 2017). Similarly, the mild negative trend between BMI and VO_2max further suggests that higher body mass, particularly from fat, may impair relative oxygen uptake capacity. Conversely, the weak or flat correlations between muscle mass or fat-free mass and VO_2max may reflect the competing effects of lean mass on absolute versus relative oxygen consumption. While muscle tissue supports greater aerobic capacity, it also contributes to total body mass, thereby influencing the denominator in VO_2max calculations (ml/kg/min).

Several limitations are taken into consideration when interpreting these findings. The sample size was relatively small, which limits generalizability and may have reduced the ability to detect statistically meaningful relationships. The cross-sectional nature of the study also prevents causal inferences and may not account for training adaptations that occur over a season. Additionally, the study did not differentiate between positional roles within Rugby 7s, which could have provided further insight into how specific physical demands relate to aerobic capacity (Duthie, 2006; Brazier et al., 2020).

Future research should address these limitations by including larger and more diverse samples across multiple teams and competitive levels. A longitudinal design would help assess how changes in body composition over time impact VO_2max and overall performance. Further exploration of positional differences, recovery metrics, and training responses could also deepen the understanding of how aerobic and structural attributes interact in Rugby 7s. Incorporating additional performance indicators, such as sprint speed, agility, and lactate threshold, may provide a more complete picture of an athlete's fitness profile.

V. CONCLUSION

In conclusion, this study found no statistically significant correlation between body composition parameters and VO_2max among male and female university Rugby 7 athletes. However, trends observed in the data such as the negative associations between body fat percentage, BMI, and VO_2max reflect patterns noted in previous literature. These findings suggest that while body composition is an important factor in athletic performance, its relationship with aerobic capacity is multifactorial and complex. The results highlight the need for a more comprehensive and individualized approach to athlete assessment and conditioning. Future studies with larger and more diverse samples, positional analysis, and longitudinal designs may provide deeper insight into how structural attributes like muscle mass and fat distribution influence cardiorespiratory fitness and performance in rugby and other team sports.

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