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RELATIONSHIP BETWEEN BODY COMPOSITION AND FITNESS PERFORMANCE AMONG MALAYSIAN STUDENT-ATHLETES

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Abstract

This study investigates the relationship between body composition and fitness performance among student-athletes at Sultan Idris Education University, Malaysia. A cross-sectional correlational design was employed, involving 94 student-athletes (57 males and 37 females) from various sports disciplines. Body composition parameters including body fat percentage, muscle mass, and body mass index (BMI) were assessed alongside physical performance components such as speed (30-meter sprint), muscular strength (grip strength), balance (Stork test), agility (T-test), flexibility (Sit-and-Reach), explosive power (vertical jump), and cardiovascular endurance (VO_2 max). The results revealed significant relationships between body composition and performance metrics. Muscle mass was positively correlated with grip strength ($r = 0.873$, $p < 0.01$), vertical jump height ($r = 0.599$, $p < 0.01$), and agility ($r = -0.584$, $p < 0.01$), highlighting its importance in athletic performance. In contrast, body fat percentage was negatively associated with VO_2 max ($r = -0.528$, $p < 0.01$), explosive power ($r = -0.703$, $p < 0.01$), and sprint speed ($r = 0.812$, $p < 0.01$), indicating a detrimental effect on performance. These findings underscore the critical role of optimizing body composition, specifically by increasing muscle mass and reducing body fat, for improving athletic performance. The study offers valuable insights for coaches, trainers, and sports scientists in designing evidence-based training and nutritional interventions while also contributing to the limited body of research on university student-athletes in Malaysia.

Keywords: Body Composition, Physical Fitness, Student-Athlete, Fitness Components, Sports Performance

INTRODUCTION

Student-athletes play a vital role in the development of high-performance sports, and two key determinants of their success are body composition and physical performance. Body composition comprising body fat percentage, skeletal muscle mass, and body mass index (BMI) is a crucial indicator of an individual's health and athletic potential. Physical performance encompasses various fitness components such as speed, strength, endurance, agility, balance, and flexibility, all of which are essential to competitive success. Previous studies have shown that body composition significantly influences athletic performance. For instance, higher muscle mass is associated with improved outcomes in strength and power activities such as vertical jumps and grip strength tests, while a higher body fat percentage tends to negatively affect performance in speed and endurance tasks (Ferreira et al., 2024; Kochman et al., 2022).

Hernandez-Martinez et al. (2024) reported a strong correlation between fat-free mass and performance metrics in professional basketball players, reinforcing the idea that lean mass contributes positively to athletic capability. Similarly, Akdoğan et al. (2022) demonstrated that excessive body fat adversely affects performance in amateur soccer players. Laursen and Jenkins (2002) further discussed physiological adaptations from high-intensity interval training (HIIT), emphasizing its potential in improving fitness and body composition. Moreover, Oukheda et al. (2023) highlighted the importance of maintaining an optimal balance between lean and fat mass for both health and sports performance.

Despite these insights, most existing research has centered on professional athletes or the general population. Limited evidence exists regarding university-level student-athletes, particularly in the Malaysian context. This lack of specific data hinders the development of tailored training and nutrition programs that consider the unique physiological profiles of student-athletes at institutions such as Sultan Idris Education University (UPSI) (Jaremków et al., 2024; Kochman et al., 2022; Oukheda et al., 2023). Understanding these relationships is crucial for designing effective performance enhancement strategies. For instance, males often demonstrate superior strength and speed, whereas females may excel in agility and balance (Laursen & Jenkins, 2002). Therefore, analyzing the association between body composition and performance across genders and sports disciplines may provide deeper insight into the factors that contribute to athletic success.

Given this background, the present study aims to address this research gap by examining the relationship between body composition and physical performance among UPSI student-athletes. The findings are expected to offer theoretical and practical guidance for optimizing the training, nutrition, and performance development of student-athletes, and may serve as a reference for sports science initiatives across other universities (Redondo-Flórez et al., 2022).

MATERIALS AND METHOD

Research Design

This cross-sectional correlational study was conducted from October to November 2024 to investigate the relationship between body composition and physical fitness performance among Malaysia Juara student-athletes at Sultan Idris Education University (UPSI). The primary objective was to examine how body composition indicators such as muscle mass and body fat percentage relate to key components of physical fitness, including strength, speed, agility, balance, muscular endurance, and aerobic capacity. The cross-sectional design enabled a comprehensive assessment of athletes' physical fitness at a specific point in time, allowing for comparisons across different sports disciplines. The study adhered to the ethical principles outlined in the Declaration of Helsinki. Ethical approval was granted by the Research Ethics Committee of Sultan Idris Education University (Reference Number: 2024-0092-106-01), and all participants provided written informed consent before participating in the study.

Participants

This study involved a total of 94 student-athletes from Sultan Idris Education University (UPSI), aged between 19 and 22 years. The participants were selected using purposive sampling based on specific inclusion criteria. They were active university athletes with at least one year of enrollment and had consistent involvement in training and competitions in either team or individual sports. This selection aimed to ensure that all participants had sufficient athletic experience to complete the physical performance tests meaningfully. Individuals with recent or chronic injuries, medical conditions such as asthma or hypertension, or those unable to participate fully in physical activity were excluded from the study. Additionally, students aged above 22 years (born before 1 July 2000) were not eligible. Before data collection, all participants provided informed consent.

Outcome Measures

Body composition measurements

Two primary methods were employed to assess body composition: Body Mass Index (BMI) and InBody bioelectrical impedance analysis (BIA). BMI was calculated using the standard formula: weight (kg) divided by height squared (m^2). The BMI aimed to provide a rapid, general assessment of whether an individual was underweight, normal weight, overweight, or obese. While BMI is considered valid and reliable for population-level trends with a sensitivity of 100% and specificity of 81% among athletes (Grams et al., 2023) it is limited in distinguishing between muscle and fat mass in athletic populations.

InBody BIA was utilized to measure detailed body composition, including muscle mass, body fat percentage, and segmental distribution of fat and lean mass. This method exhibits high reliability, with intraclass correlation coefficients (ICCs) ranging from 0.96 to 0.99 for body fat percentage and lean body mass (McLester et al., 2020). The procedure necessitated participants to abstain from food, drink, and exercise for a period of 2–4 hours prior to testing. During the test, participants stood barefoot on the device and held hand electrodes while maintaining an upright posture. Results were accessible within 1–2 minutes.

Fitness Performance Assessments

To comprehensively evaluate fitness performance, a series of standardized tests were meticulously conducted, each designed to assess specific components of physical fitness. The assessment of speed was undertaken using the 30-meter sprint run, a widely recognized test for measuring linear speed. Participants were required to complete three sprint trials over a clearly marked 30-meter distance, with the fastest time recorded to the nearest 0.01 second. This test has been previously validated for its high reliability, as evidenced by Intraclass Correlation Coefficients (ICC) ranging from 0.91 to 0.96, as reported by Fernandes-Da-Silva et al. (2021). Muscular strength was evaluated through a grip strength test utilizing a handgrip dynamometer. This test involved participants performing three maximal effort squeezes per hand following a proper warm-up protocol. The highest recorded value was considered the measure of grip strength. The reliability of this test has been extensively documented, with ICC values ranging from 0.89 to 0.97, as indicated by Cuenca-Garcia et al. (2022).

Balance was assessed using the Stork Test, a static balance evaluation tool. Participants were instructed to balance on one foot while placing the opposite foot against the inside knee, maintaining hands on hips and eyes open. The duration of balance was recorded until loss or compromise of form. The highest performance from three trials was selected. Hoffman et al. (1998) reported reliability ranging from 0.75 to 0.88. Explosive power was measured using the vertical jump test, which required participants to perform three maximal vertical jumps after their standing reach was measured. The highest jump height, calculated as the difference from the standing reach, was recorded. The vertical jump test demonstrated excellent reliability, with ICC values ranging from 0.89 to 0.97, as reported by Hammami et al. (2015). Agility was assessed through the T-Test, which involves a combination of sprinting, side shuffling, and backpedaling between four cones arranged in a “T” shape. Participants completed three trials, and the fastest time was recorded. The T-Test exhibited high reliability, with ICCs between 0.95 and 0.98, as indicated by Cuenca-Garcia et al. (2022). Muscular endurance was assessed using the 1-minute curl-up test, wherein participants were required to perform as many correctly executed curl-ups as feasible within a one-minute time frame. This test has been demonstrated to exhibit high reliability, with intraclass correlation coefficients (ICCs) ranging from 0.85 to 0.94, as reported by Cuenca-Garcia et al. (2022). Aerobic capacity was quantified employing both the Yo-Yo Intermittent Recovery Test and the Beep Test. In the Yo-Yo test, participants ran back and forth over a 20-meter distance with intermittent 10-second recovery intervals, synchronously following a progressive audio signal. The total distance covered prior to losing pace on two consecutive occasions was recorded. This test has reported reliability ranging from 0.78 to 0.95, as noted by Bangsbo et al. (2008). In the Beep Test, participants ran back and forth over a 20-meter course, maintaining a steady pace with increasing audio beeps. The final level and shuttle completed were recorded. The Beep Test has been reported to have a high ICC range of 0.89 to 0.95, as indicated by Léger et al. (1988).

Procedure

All assessments were carried out at the designated sports science laboratories and testing fields of Sultan Idris Education University (UPSI). Each testing session began with a standardized dynamic warm-up lasting 5 to 10 minutes, specifically targeting the muscle groups relevant to the performance tests. Prior to testing, participants were thoroughly briefed on the procedures and safety protocols. Anthropometric measurements, including height and weight, were recorded first, followed by body composition analysis using the InBody device. Physical fitness tests were then administered in a fixed sequence to minimize fatigue-related interference: sprint, vertical jump, agility T-Test, grip strength, single-leg balance, curl-up test, and either the Yo-Yo Intermittent Recovery Test or the Beep Test, depending on the sport type (intermittent or continuous). All tests were conducted by trained sport science personnel under standardized conditions to ensure accuracy, reliability, and reproducibility.

Data Analysis

This study employed IBM SPSS Statistics for Windows version 26.0 (Armonk, NY: IBM Corporation) for data analysis. Descriptive statistics were employed to summarize participant anthropometry and fitness test outcomes, based on gender. Pearson correlation coefficients were computed to assess the relationships between body composition variables (body mass index, body fat percentage, lean muscle mass) and fitness performance metrics (sit and reach distance, sprint and agility time, grip strength, jump height, balance duration, curl-ups, VO2 max). The significance level was set at $p < 0.05$.

RESULTS

Descriptive Statistics

Descriptive statistics were conducted on 94 student-athletes, 57 males and 37 females, to analyze body composition and fitness test outcomes. Males had an average height of 170.5 cm, weight of 67.7 kg, arm span of 174.4 cm, and leg length of 82.6 cm, while females averaged 159.7 cm in height, 58.7 kg in weight, 160.9 cm in arm span, and 79.6 cm in leg length. Males had a higher muscle mass (30.5 kg) and lower body fat percentage (17.8%) compared to females (21.8 kg muscle mass, 30.6% body fat). Males' resting metabolic rate was 1536 kcal, and females was 1238 kcal. In physical performance, males had a faster 30-meter sprint time (4.24 seconds) and higher handgrip strength (43.3 kg dominant hand) than females (5.12 seconds sprint time, 27.7 kg dominant hand). Balance showed high variability, with males averaging 17.94 seconds and females 8.20 seconds. Flexibility was similar, with males averaging 37.0 cm and females 34.8 cm. Vertical jump performance was notably higher for males (51 cm) than females (36 cm). Agility was more stable in males (10.70 seconds) than females (12.46 seconds). Core endurance averaged 27 repetitions for males and 23 for females. Males had a higher estimated VO_2max (42.6 ml/kg/min) than females (36.2 ml/kg/min). These results underscore individual variations in body composition, strength, power, balance, and endurance across genders (Table 1).

Table 1. Descriptive data on participants' body composition and fitness performance (n = 94)

	Male (n = 57)		**Female (n = 37)**	
Variable	**Mean ± SD**	**Range**	**Mean ± SD**	**Range**
Standing Height (cm)	170.5 ± 5.2	159.9–183.5	159.7 ± 6.0	147.1–172.0
Body Weight (kg)	67.7 ± 15.4	49.7–157.6	58.7 ± 12.8	38.4–103.7
Arm Span (cm)	174.4 ± 7.0	161.0–189.9	160.9 ± 7.5	147.0–175.0
Leg Length (cm)	82.6 ± 5.5	73.8–104.1	79.6 ± 7.1	69.4–97.7

continued

Muscle Mass (kg)	30.5 ± 4.0	23.8–40.9	21.8 ± 3.1	15.8–29.2
Body Fat (%)	17.8 ± 6.0	9.2–33.9	30.6 ± 6.3	20.3–49.6
Resting Metabolic Rate (kcal)	1536 ± 145	1290–1904	1238 ± 111	1016–1502
30m Sprint (s)	4.24 ± 0.27	3.79–5.28	5.12 ± 0.50	4.40–7.04
Handgrip Strength - Dominant (kg)	43.3 ± 7.0	32.0–58.5	27.7 ± 4.5	19.2–37.4
Handgrip Strength - Non-Dominant (kg)	39.4 ± 6.6	29.0–53.4	25.0 ± 4.4	17.5–35.0
Stork Stand (s)	17.94 ± 17.35	1.95–68.08	8.20 ± 8.01	1.61–39.32
Sit and Reach (cm)	37.0 ± 6.2	16.0–48.5	34.8 ± 5.9	22.0–46.0
Vertical Jump (cm)	51 ± 9	31–75	36 ± 5	25–48
Agility T-Test (s)	10.70 ± 0.72	9.62–13.07	12.46 ± 0.93	10.72–15.48
Curl-Up Test (reps)	27 ± 9	8–51	23 ± 7	4–35
Estimated VO_2max (ml/kg/min)	42.6 ± 4.4	32.5–56.0	36.2 ± 5.8	20.4–48.0

Inferential Statistics

The correlation analysis (Table 2) examined relationships between body composition (BMI, muscle mass, body fat percentage) and performance-related fitness measures (sprint speed, strength, balance, flexibility, power, agility, core endurance, cardiorespiratory fitness). BMI showed weak correlations with most outcomes, except for a weak but significant positive correlation with grip strength ($r = 0.320$, $p < 0.01$), suggesting higher BMI may enhance upper body strength. BMI was not significantly associated with dynamic fitness performance and showed a non-significant negative correlation with VO_2 max ($r = -0.142$). Muscle mass showed more robust associations, with a strong positive correlation with grip strength ($r = 0.873$, $p < 0.01$) and vertical jump performance ($r = 0.599$, $p < 0.01$), while negatively correlated with 30-meter sprint time ($r = -0.646$, $p < 0.01$) and agility T-test time ($r = -0.584$, $p < 0.01$), indicating enhanced explosive power, sprinting speed, and agility. Body fat percentage was predominantly associated with negative outcomes, with strong negative correlations with VO_2 max ($r = -0.528$, $p < 0.01$) and vertical jump performance ($r = -0.703$, $p < 0.01$), suggesting reduced aerobic capacity and lower-body power. Body fat percentage was also strongly and positively correlated with 30-meter sprint time ($r = 0.812$, $p < 0.01$) and agility T-test time ($r = 0.662$, $p < 0.01$), suggesting impaired speed and agility.

Table 2. Correlation matrix on body composition and fitness performance

	BMI	Muscle Mass (kg)	Body Fat (%)	30m Sprint (Sec)	Dominant Handgrip (kg)	Stork Stand (s)	Sit and Reach (inch)	Vertical Jump (inch)	T-Test (sec)	1- min Curl-Up (reps)	VO2 max (ml/kg/min)
BMI	1										
Muscle Mass (kg)	0.43**	1									
Body Fat (%)	0.490*	-0.54**	1								
30m Sprint (Sec)	0.11	-0.65*	0.81**	1							
Dominant Handgrip (kg)	0.32**	0.87**	-0.55**	-0.70**	1						
Stork Stand (s)	0.02	0.39**	-0.34**	-0.38**	0.42**	1					
Sit and Reach (inch)	0.1	0.16	-0.15	-0.12	0.18	-0.01	1				
Vertical Jump (inch)	-0.01	0.60**	-0.70**	-0.79**	0.65**	0.31**	0.31**	1			
T-Test (sec)	0.04	-0.58**	0.66**	0.83**	-0.65**	-0.31**	-0.17	-0.64**	1		

continued

1- min Curl-Up (reps)	0.08	0.35**	-0.37**	-0.33**	0.37**	0.18	0.11	0.34**	-0.33**	1	
VO2 max (ml/kg/min)	-0.14	0.35**	-0.53**	-0.62**	0.39**	0.13	0.08	0.35**	-0.65**	0.25*	1

** Correlation is significant at the 0.01 level
* Correlation is significant at the 0.05 level

DISCUSSION

This study sought to elucidate the correlation between body composition and physical fitness performance among Malaysian university athletes. The findings unveiled several significant trends that can serve as guiding principles for athletic training and monitoring programs. Muscle mass exhibited a consistent positive correlation with performance in various fitness components, particularly in strength (handgrip test), power (vertical jump), speed (30 m sprint), and agility (Agility T-Test). Athletes with higher muscle mass demonstrated superior performance in these areas, suggesting that lean tissue significantly contributes to force production, speed, and dynamic movement coordination. These findings corroborate existing literature that underscores the role of muscle mass in explosive and high-intensity actions prevalent in competitive sports (Ferreira et al., 2024; Hernandez-Martinez et al., 2024)

Conversely, body fat percentage exhibited a negative association with the majority of fitness performance tests. Elevated fat percentage was associated with diminished outcomes in endurance (Yo-Yo test), power (vertical jump), and agility (Agility T-Test), indicating that excess fat may function as a non-functional mass that impedes movement efficiency and cardiovascular capacity. This aligns with previous studies that highlight the detrimental impact of fat mass on aerobic and anaerobic performance (Akdoğan et al., 2022). Body Mass Index (BMI) exhibited weak or inconsistent associations with performance across the tests. While widely utilized as a general health indicator, its inability to distinguish between lean and fat mass restricts its applicability in athletic populations. Consequently, sport scientists and coaches should prioritize the utilization of more comprehensive body composition metrics, such as fat-free mass and segmental analysis, when assessing athletic fitness and readiness (Grams et al., 2023).

A key observation in this study was the substantial correlation between muscle mass and enhanced performance across various physical fitness domains. This underscores the significance of resistance training and muscle development in augmenting athletic performance. Conversely, the adverse trends associated with elevated body fat percentage indicate that training programs should also incorporate strategies aimed at fat reduction, such as high-intensity interval training (HIIT) or periodized aerobic conditioning. Differences in performance outcomes also mirrored sport-specific demands. Athletes engaged in sports that necessitate speed and power—including sprinting, football, and basketball—typically exhibited higher muscle mass and lower fat levels, contributing to their superior sprint and jump test scores. In contrast, athletes from endurance-based sports performed better in the Yo-Yo test, consistent with their training background. These findings affirm that body composition influences performance differently depending on the nature of the sport (Akdoğan et al., 2022; Bangsbo et al., 2008).

Gender differences were not the primary focus of this study but could be inferred from the general understanding of male and female physiological profiles. Males are likely to possess greater muscle mass and strength, while females typically exhibit superior flexibility. These inherent differences should be considered when designing training programs to ensure their gender-appropriateness and individualized nature (Laursen & Jenkins, 2002). This study contributes to the growing body of evidence that optimized body composition—characterized by higher muscle mass and lower fat percentage is pivotal for athletic performance. The findings support the integration of regular body composition monitoring and individualized training interventions as integral components of sports development programs.

However, several limitations should be acknowledged. While bioelectrical impedance analysis (BIA) is a practical tool, its influence may be affected by hydration status and other external factors. The sample, limited to athletes from a single university, may restrict the generalizability of the findings. Furthermore, other variables such as nutrition, sleep quality, and training history were not controlled in this study. Future research should consider larger and more diverse athlete populations, employ more precise assessment tools (e.g., DXA), and control for lifestyle and training variables.

CONCLUSION

In summary, this study demonstrated that body composition plays a significant role in influencing physical fitness performance among Malaysian university athletes. Higher muscle mass was consistently associated with superior performance in strength, power, speed, and agility tests, while higher body fat percentage was generally linked to poorer outcomes across most fitness components. These findings reinforce the importance of developing and maintaining optimal body composition, specifically increasing lean mass and reducing excess fat, for enhancing athletic performance.

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