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Body Composition and Macronutrient Intake are Correlated with Physical Fitness of Basketball Student-Athlete

Rafly Yusuf Muhammad[1], Satwika Arya Pratama[1], Endang Sri Wahyuni[1], Noor Rohmah Mayasari[1], Cleonara Yanuar Dini[1]

[1] Universitas Negeri Surabaya, Indonesia

Corresponding Author: Rafly Yusuf Muhammad, raflyyusufm@gmail.com
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ABSTRACTS

Purpose: This study aims to investigate the correlation between body composition and macronutrient intake on the physical fitness of basketball student-athletes. Physical fitness is essential for basketball athletes, enabling them to engage in training and competition effectively and efficiently. Several factors influence physical fitness, including body composition and nutrient intake. Body composition significantly impacts the performance of basketball athletes, with anthropometric measurements affecting hand grip strength crucial for ball handling and throwing. Optimal nutrient intake is essential for maximizing athletic performance. Student-athletes have not reached the pro level in terms of nutrition knowledge, quantity and intensity of the match, and economic aspects.

Materials and Methods: This is a quantitative study with a cross-sectional design. Participants included 32 male and 16 female basketball student-athletes aged 19-22. Body composition (fat and muscle percentage) was measured using Bioelectrical Impedance Analysis (BIA) Omron Karada Scan HBF-375, macronutrient intake (energy, protein, fat, and carbohydrate) was assessed using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ), and physical fitness was evaluated using the Multi-Stage Fitness Test (MFT). The correlation between variables was analyzed using Pearson and Spearman correlation tests.

Result: The findings revealed a significant correlation between body fat percentage ($p = 0.001$; $r = -.477^{*}$), subcutaneous fat ($p = 0.000$; $r = -.622$), and muscle mass ($p = 0.000$; $r = .739$) with physical fitness. Additionally, a significant correlation was found between energy intake ($p = 0.002$; $r = .436$), protein intake ($p = 0.000$; $r = .518^{*}$), and fat intake ($p = 0.001$; $r = .446$) and physical fitness. However, carbohydrate intake ($p = 0.117$; $r = .229$) showed no significant correlation with physical fitness.

Conclusion: This study concludes that body composition, specifically fat percentage and muscle mass, has a significant correlation on physical fitness. Energy, protein, and fat intake are significantly correlated to physical fitness, while carbohydrate intake does not demonstrate a significant correlation.

Keywords: Body composition; Macronutrient; Physical fitness; Student-athlete; Basketball.

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INTRODUCTION

Basketball is a highly dynamic sport that demands advanced physical fitness and includes various specific activities, such as sprinting, jumping, quick directional changes, acceleration, and deceleration (Cao et al., 2024). To perform effectively against their opponents, basketball players must possess strength, speed, resilience, and agility (Tarigan et al., 2023). The ability to continuously perform high-intensity actions during the game is essential for basketball players (Gottlieb et al., 2021), highlighting the importance of physical fitness in achieving peak performance. Physical fitness represents an individual's ability to perform physical tasks efficiently without causing excessive fatigue (Çemç & Şahin, 2024; Iqbal et al., 2024). It is a vital aspect for student-athletes. Students who maintain a physically fit condition can participate in academic activities, training, and competitions to their fullest potential (Gunarsa & Wibowo, 2021; Setia & Winarno, 2021). A study conducted by Permatasari (2018) on the fitness levels of basketball student-athletes in Surabaya found that 33% of male athletes and 0% of female athletes showed severely inadequate fitness, while 19.1% of male athletes and 5.3% of female athletes had inadequate fitness. This information suggests that most student-athletes do not meet physical fitness standards.

Nutritional status plays a crucial role in physical fitness, with body composition being one of its key components (Jeukendrup & Gleeson, 2024). Body composition is the amount of muscle, fat, bone, and water that compose the human body (Ward & Noland, 2020). It is recognized as a key factor influencing athletic health and performance, making its assessment essential for evaluating the effectiveness of an athlete's diet and nutritional status (Campa et al., 2021). Body composition significantly impacts the performance of basketball athletes, as anthropometric measurements influence grip strength, which is essential for holding and throwing the ball in basketball (Delgado-Floody et al., 2017). A preliminary survey conducted on student-athletes revealed that 11 out of 15 athletes had a body fat percentage exceeding the ideal range for basketball players, which is between 12-16%, with their fat percentage being above 16% (Jeukendrup & Gleeson, 2024), this indicates that a majority of basketball student-athletes fall into the category of having excess body fat.

An athlete's diet must provide all the essential nutrients necessary for maintaining health, enhancing training, and supporting stamina, which ultimately contributes to health, fitness, and improved performance (Afandi & Avandi, 2022; Amawi et al., 2024; Kaufman et al., 2023). Adequate energy intake significantly supports fitness, power, and cardiorespiratory resistance (Arisanty et al., 2024). A study conducted by Fitriani (2021) showed that 25% of student-athletes did not fulfill their energy requirements, 32% of student-athletes didn't fulfill their carbohydrate requirement, 69,5% of student-athletes didn't fulfill their protein requirement, and 78% consumed excessive fat. Preliminary research conducted by the author on student-athletes revealed that 33% of athletes did not meet the recommended protein intake of 1.2-2.0 g/kg/day, while 13% of athletes exceeded this recommended daily protein allowance. Additionally, 20% of athletes fell short of the suggested carbohydrate intake of 5-7 g/kg/day, while 33% exceeded the recommended daily amount. These findings suggest that the overall macronutrient intake among basketball student-athletes is generally below the nutritional adequacy levels, except for fat.

Student-athletes need to develop themselves in order to reach the pro level. Student-athletes still have limited nutrition knowledge. A study conducted by Nabila (2024) showed that 59% of student-athletes have a medium level of balanced diet knowledge, 48% have a negative

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attitude toward a balanced diet, and 48% have negative behavior toward a balanced diet. Student-athletes participate in a lower number of matches with less intensity compared to professional athletes. A study by Dewi (2020) showed that 94,4% of university students have a monthly allowance of <1.500.000,- IDR. Economic status could affect the students' dietary intake. Given the observed phenomena among these basketball athletes, the aim of this study is to investigate the correlation between body composition, macronutrient intake, and the physical fitness of student-athletes.

METHODS

***Study Participants*:** The study involved a population of 80 student-athletes. A purposive sampling technique was conducted, resulting in a sample size of 45. The criteria for the sample were: 1) An active member of the university basketball club; 2) Aged 19-22 when the research was conducted; 3) Willing to participate in the study by agreeing to informed consent. The criteria for exclusion were: 1) Have had an injury in the last month; 2) Chronic disease; 3) Did not attend the training in the last 3 months.

***Study Organization*:** This study is a quantitative study with a cross-sectional design. This study examines the correlation between body composition and macronutrient intake on physical fitness. The independent variables in this study were body composition (percentage of body fat and muscle mass) and macronutrient intake (amount of energy, carbohydrates, protein, and fat consumed). The dependent variable was physical fitness, which is measured with VO_2 max. Three instruments were used for this research. Bioelectrical Impedance Analysis (BIA) Omron Karada Scan HBF-375 was used to measure body composition. BIA works by measuring how different tissues in the body resist the flow of electricity and then applying formulas to estimate the proportions of fat and muscle. Participants are asked to wear minimal clothes and take off metal jewelry. Participants' age, sex, and height data are entered, and then they step onto the BIA and hold the handle as the BIA calculates the body composition. Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) was used to assess macronutrient intake. SQ-FFQ recorded the participant's dietary intake for a one-month period. Multi-stage Fitness Test (MFT) is used to evaluate physical fitness. MFT involves running back and forth between two lines 20 meters apart, keeping pace with a series of recorded beeps. Participants must reach the line before the beep sounds. They are eliminated from the test if they fail to reach the line twice in a row.

***Statistical Analysis*:** Univariate analysis was performed to generate frequency and percentage distributions for both independent and dependent variables, aiming to describe the values of body composition (percentage of fat and muscle mass), average macronutrient intake (energy, protein, carbohydrates, fat), and levels of physical fitness. Statistical analysis examined the correlation between body composition and macronutrient intake on VO_2Max. Firstly, the Shapiro-Wilk normality test was performed to assess the normality of the data. The Pearson correlation test was applied if the data were normally distributed, while the Spearman correlation test was used for non-normally distributed data. A significant correlation is found if the p-value is <0,05. A stronger correlation is concluded if the r-value approaches 1 or -1. If the value is positive, the correlation is directly proportional, meaning they move in the same direction, while a negative value means they move in the opposite direction.

RESULT

Table 1. Respondent characteristic

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Category	Male (Mean±SD)	Female (Mean±SD)	Overall (Mean±SD)
Age	18,9±0,8	18,6±0,9	18,8±0,7
Height (cm)	174,1±7,1	162,1±6,1	169,7±8,8
Weight (kg)	64,81±12,4	53.38±11,1	62,4±12,1
BMI (kg/m²)	21,9±3,5	21,02±3,1	21,6±3,3
Fat Mass			
Body Fat (%)	15,4±6,1	22,59±6,3	17,5±7,0
Subcutaneous Whole (%)	11,2±5,4	21,07±4,4	14.7±6,8
Subcutaneous Trunk (%)	9,4±4,6	18,3±9,1	12.8±7,7
Subcutaneous Arm (%)	16,8±5,9	34,7±5,6	24.3±10,2
Subcutaneous Leg (%)	15,6±6,1	31,5±5,2	22.3±9,4
Muscle Mass			
Skeletal Whole(%)	36,5±2,8	27,6±3,2	32.7±5,2
Skeletal Trunk (%)	30,8±3,3	23,7±1,9	27.3±4,4
Skeletal Arm (%)	40,8±3,8	31,9±4,0	37±5,7
Skeletal Leg (%)	52,7±6,5	41,2±2,4	47.7±8,9
Macronutrient Intake			
Energy (kkal)	2064,4±211,3	1735,1±386,6	1935,4±327,4
Protein (g)	71,8±14,6	61,6±28,7	66,1±16,5
Fat (g)	72,4±14,7	59,3±20,6	66,7±16,7
Carbohydrate (g)	273,3±50,5	233,7±80,9	260,3±61,8

Table 1 indicates that male and female athletes' mean age and BMI are similar. Male athletes have a greater mean height and weight than female athletes. Female athletes show a higher mean body fat percentage and subcutaneous fat than male athletes, while male athletes show a higher mean skeletal muscle mass. Male athletes also show a higher macronutrient intake than female athletes.

Table 2. Frequency distribution of macronutrient intake measurement result

Category	Energy		Protein		Fat		Carbohydrate	
	Male	Female	Male	Female	Male	Female	Male	Female
Severe Deficit (<70%)	19 (59,4%)	5 (31,2%)	15 (46,9%)	8 (50%)	1 (3,1%)	2 (12,5%)	19 (59,4%)	8 (50%)
Moderate Deficit (70-79%)	11 (34,4%)	3 (18,8%)	7 (21,9%)	3 (18,8%)	9 (28,1%)	1 (6,3%)	8 (25%)	2 (12,5%)
Light Deficit (80-89%)	2 (6,2%)	4 (25%)	3 (9,4%)	1 (6,3%)	5 (15,6%)	6 (37,5%)	5 (37,5%)	1 (6,3%)
Sufficient (90-110%)	-	3 (18,8%)	7 (21,9%)	4 (25%)	10 (31,3%)	2 (12,5%)	-	3 (18,8%)
Excessive (>110%)	-	1 (6,2%)	-	-	7 (21,9%)	5 (31,3%)	-	2 (12,5%)

Table 2 shows the distribution of athletes' macronutrient intake. The majority of the athletes, both male and female, fall into the severe deficit category on energy, protein, and carbohydrate intake. 31,3% of male athletes fulfilled their fat requirements. The majority of female athletes fall into the light deficit category of fat intake. No male athletes fulfilled their energy and carbohydrate needs.

Table 3. Multi-stage fitness test result

Category	Male		Female		Overall	
	n	%	n	%	n	%
Good	1	3	-	-	1	2
Above Average	1	3	-	-	1	2
Average	11	34	1	5	12	24
Below Average	10	31	1	5	11	22
Poor	8	25	4	22	12	24
Very Poor	1	3	12	66	13	26

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Table 3 shows the MFT results. Most male athletes have average VO_2 max, while most female athletes have very poor VO_2 max. Only two of 32 male athletes have above-average or greater VO_2 Max, and no female athletes have above-average VO_2 Max.

Table 4. Result of correlation between body composition and macronutrient intake on physical fitness

	Physical Fitness		
	n	**r**	**p**
Fat Percentage			
Body Fat	48	-.477**	.001
Subcutaneous Whole	48	-.622**	.000
Subcutaneous Trunk	48	-.656**	.000
Subcutaneous Arm	48	-.742**	.000
Subcutaneous Leg	48	-.746**	.000
Muscle Mass			
Skeletal Whole	48	.739**	.000
Skeletal Trunk	48	.715**	.000
Skeletal Arm	48	.767**	.000
Skeletal Leg	48	.677**	.000
Macronutrient Intake			
Energy	48	.436**	.002
Protein	48	.518**	.000
Fat	48	.446**	.001
Carbohydrate	48	.229	.229

**. Correlation are significant on 0.01 level (2-tailed).

Table 4 reveals that fat body composition is significantly correlated (p<0,05) with physical fitness of the student-athletes. Body and subcutaneous fat correlate negatively with physical fitness, while muscle mass positively correlates with physical fitness. Energy, protein, and fat intake positively correlate (p<0,05) with physical fitness, but carbohydrate intake shows no correlation with physical fitness.

DISCUSSION

The Pearson and Spearman correlation test was conducted to determine the correlation between body composition and macronutrient intake on physical fitness. The correlation test results indicate a significant correlation ($p<0.05$) between body fat percentage, subcutaneous fat, and physical fitness. The correlation strength is moderately strong, and a negative correlation was found. Therefore, a lower body fat percentage corresponds to a higher physical fitness level. This finding aligns with several studies that reported a significant negative correlation between fat percentage and physical fitness (Kurnia et al., 2020; Vijaykumar et al., 2021). It has been found that a greater percentage of SMO_2 is present when a person has a lower body fat (Vasquez-Bonilla et al., 2022). Excess body fat can burden muscle's ability to absorb oxygen (Gantarialdha, 2021). The intense physical demands of basketball, including jumping, sprinting, and rapid changes of direction, create a substantial strain on players bodies, making a body composition with lower fat mass beneficial for their performance (Čović et al., 2023; Hernandez-Martinez et al., 2024).

Muscle mass significantly correlated with physical fitness ($p<0.05$). A moderately strong positive correlation indicates that greater muscle mass improves physical fitness. This finding is supported by Latifah's research (2019), which found a significant correlation between muscle mass and physical fitness among stop-and-go athletes. Muscle tissue consists of active cells capable of storing glycogen, which is utilized for energy during exercise (Latifah et al., 2019). Consequently, a strong linear relationship exists between muscle mass and adolescent VO_2

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Max across different ages, genders, and Body Mass Index (BMI) categories (Senanayake et al., 2021).

Energy, protein, and fat showed a significant positive correlation with the physical fitness of student-athletes ($p<0.05$). Meanwhile, carbohydrate intake did not show any significant correlation with physical fitness. These results align with Rahmah (2020), which showed a significant correlation between energy, protein, and fat intake and physical fitness.

Energy intake is a key factor in sports performance; it plays a crucial role in physical fitness by providing the necessary fuel for daily activities and structured training sessions (Castillo et al., 2022; Hargreaves & Spriet, 2020). Inadequate energy intake can negatively impact an athlete's performance; athletes may encounter obstacles in both training adaptations and recovery processes, leading to decreased fat-free mass, weakened immune response, reduced bone mineral density, increased risk of injuries, and a higher likelihood of experiencing overtraining symptoms (Amawi et al., 2024). Thus, managing energy intake is fundamental for athletes and individuals seeking to optimize their physical fitness and health.

Protein intake combined with exercise can boost muscle protein synthesis rates, improving the skeletal muscle's ability to adapt to extended training (Joanisse et al., 2021; Yuniarti et al., 2021). Increased protein intake will increase muscle strength and endurance performance, including aerobic and anaerobic capacity (Nunes et al., 2022; Zhao et al., 2024). Athletes should consume 1.2–2.0 g/kg/day of protein to maintain protein balance (Davis et al., 2022). If insufficient protein is consumed, an athlete will experience a negative nitrogen balance, indicating protein catabolism and slow recovery, leading to muscle wasting, injury, disease, and exercise intolerance (Kerksick et al., 2018).

This study found that fat intake is positively correlated with physical fitness. During physical activities, skeletal muscles can utilize fat or carbohydrate oxidation to meet the body's energy demands (Katare et al., 2022; Muscella et al., 2020). At rest, fat oxidation significantly contributes to energy supply (Rahmah et al., 2020). Since the debate surrounding high-fat diets versus low-fat diets has been ongoing for a long time, it is recommended that athletes ingest 20-35% of their daily caloric intake from fats (Holtzman & Ackerman, 2021; Roberts et al., 2020). This guideline is based on research indicating that fat intake exceeding 35% of total calories often coincides with a high intake of saturated fats beyond recommended levels (Catapano et al., 2011).

In this study, carbohydrate intake did not significantly correlate with physical fitness. This finding contrasts with the studies conducted by Kuswari et al. (2019) and Rahmah et al. (2020), which reported a significant impact of carbohydrate intake on physical fitness. The lack of significance in this study may be attributed to the low carbohydrate consumption among respondents, with 77% classified as having severe carbohydrate deficits, 20% as moderate deficits, 12% as mild deficits, 6% as sufficient, and 4% as excessive. The recommended carbohydrate intake for athletes participating in team sports is typically between 6-10 g/kg, and during pre-season or very intense training sessions lasting over 4 hours, it can increase to 12 g/kg (Castillo et al., 2022).

There were limitations in this research. First, the sample size of this study is small (<50). Second, socio-economic aspects were not studied. It could provide another insight since monthly allowance could affect dietary intake. Third, hydration factor was not studied, even though it can affect BIA's reading on fat and fat-free mass. Additionally, BIA Omron Karada Scan HBF-could not display an individual's fat percentage if it was too low compared to the device's measurable range.

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Fourth, this study's cross-sectional design cannot determine causal connections or analyze behavioral changes through time. This study gives information for coaches and athletes to evaluate athlete's body composition, macronutrient intake, and physical fitness. Future research should include a socio-economic aspect of the student-athlete since it can affect the eating habits of the athletes. Future research could be conducted in a cohort design to understand better how body composition and macronutrient intake could affect physical fitness. Future research could try another type of BIA and fitness test to examine how the result will vary from different tests.

CONCLUSION

This study reveals a significant correlation between body composition and physical fitness. A higher percentage of body fat is correlated with lower levels of physical fitness, whereas increased muscle mass contributes to enhanced physical fitness. Additionally, the intake of macronutrients like energy, protein, and fat significantly correlates with physical fitness. On the contrary, carbohydrate intake shows no significant correlation with physical fitness.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in this matter.

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