

## Physical Activity Levels in Relation to Fat Mass and Muscle Mass Among Adolescents at SMA Negeri 9 Jambi City

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| Keywords:                                                               | Abstract                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
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| physical activity, body composition, muscle mass, fat mass, adolescent. | <i>Physical activity plays a crucial role during adolescence, a period characterized by rapid physical growth and development. Inadequate physical activity patterns are thought to contribute to changes in body composition, particularly muscle mass and fat mass. Although various previous studies have examined the relationship between physical activity and muscle mass and fat mass, the results obtained are still varied and inconsistent, so further studies are needed in the Indonesian adolescent population. This study aims to determine the relationship between physical activity and fat mass and muscle mass in adolescents. The study used a quantitative approach with a correlational analysis design. The respondents were students in grades X–XII of SMAN 9 Jambi City in 2025. Muscle mass and fat mass were measured using a Bioelectrical Impedance Analysis (BIA) device, while the respondents' physical activity levels were measured using a validated International Physical Activity Questionnaire (IPAQ). Data were analyzed using a correlation test to assess the strength and direction of the relationship between the variables studied. The analysis results showed no significant relationship between physical activity and fat mass (<math>p = 0.754</math>) or muscle mass (<math>p = 0.454</math>). This study concluded that physical activity had no significant relationship with fat mass and muscle mass in grades X–XII of SMAN 9 Jambi City. This finding indicates that adolescent body composition is likely more influenced by other factors, such as nutritional intake, genetics, sleep patterns, and hormonal status, so a more comprehensive approach is needed to maintain health and balance the overall body composition of adolescents. Further research with a longitudinal design is recommended to strengthen and expand these findings.</i> |
| Kata Kunci:                                                             | Abstrak                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| aktivitas fisik, komposisi tubuh, massa otot, massa lemak, remaja.      | Aktivitas fisik memiliki peranan penting selama masa remaja, periode yang ditandai dengan pertumbuhan dan perkembangan fisik yang pesat. Pola aktivitas fisik yang kurang memadai diduga dapat berkontribusi terhadap perubahan komposisi tubuh, khususnya massa otot dan massa lemak. Meskipun berbagai penelitian terdahulu telah mengkaji hubungan antara aktivitas fisik dengan massa otot dan massa lemak, hasil yang diperoleh masih beragam dan tidak konsisten, sehingga diperlukan kajian lebih lanjut pada populasi remaja Indonesia. Penelitian ini bertujuan untuk mengetahui hubungan antara aktivitas fisik dengan massa lemak dan massa otot pada remaja. Penelitian menggunakan pendekatan kuantitatif dengan desain analisis korelasional. Responden penelitian adalah siswa kelas X–XII SMAN 9 Kota Jambi pada tahun 2025. Massa otot dan massa lemak diukur menggunakan alat Bioelectrical Impedance Analysis (BIA), sedangkan tingkat aktivitas fisik responden diukur menggunakan kuesioner International Physical Activity Questionnaire (IPAQ) yang telah tervalidasi. Data dianalisis menggunakan uji korelasi untuk menilai kekuatan dan arah hubungan antar variabel yang diteliti. Hasil analisis menunjukkan tidak terdapat hubungan yang signifikan antara aktivitas fisik dengan massa lemak ( $p = 0,754$ ) maupun dengan massa otot ( $p = 0,454$ ). Penelitian ini menyimpulkan bahwa aktivitas fisik tidak memiliki hubungan yang signifikan dengan massa lemak dan massa otot pada siswa kelas X–XII SMAN 9 Kota Jambi. Temuan ini mengindikasikan bahwa komposisi tubuh remaja kemungkinan lebih dipengaruhi oleh faktor lain, seperti asupan gizi, genetik, pola tidur, dan status                                                                                                                                                                                            |

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hormonal, sehingga diperlukan pendekatan yang lebih komprehensif dalam menjaga kesehatan serta keseimbangan komposisi tubuh remaja secara menyeluruh. Penelitian lanjutan dengan desain longitudinal disarankan guna memperkuat dan memperluas temuan ini.

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## INTRODUCTION

Physical activity is defined as any bodily movement produced by skeletal muscles that requires energy expenditure, and when performed in a planned, structured, and repetitive manner with the objective of improving fitness, it is referred to as exercise. During adolescence, a period characterized by rapid growth and development, physical activity plays a crucial role not only for cardiovascular and metabolic health but also for the development of optimal body composition. Regular physical activity provides various health benefits, including improved physical fitness, cognitive function, mental health, and reduced adiposity through its influence on energy metabolism, muscle mass development, and fat mass reduction. Physical exercise can increase pulmonary ventilation by up to twentyfold compared with resting levels, demonstrating the profound physiological impact of physical activity on the human body.

Despite the well-documented benefits of physical activity, physical inactivity among adolescents has become a major global public health concern. According to the World Health Organization (WHO) in 2022, approximately 81% of school-aged adolescents worldwide aged 11–17 years did not achieve the recommended level of physical activity, with most engaging in less than 60 minutes of physical activity per day. In Indonesia, the 2023 Indonesian Health Survey (Survei Kesehatan Indonesia) reported that the prevalence of insufficient physical activity among individuals aged  $\geq 10$  years reached 37.4%, and the proportion of the population who are physically inactive remains far from the WHO target of a maximum of 28.5%. Data from the Ministry of Youth and Sports in the 2023 Sports Development Index Report further revealed that 83.55% of the 16–30 year age group had poor physical fitness, with only 5.04% classified as having good fitness. These alarming figures underscore the urgent need to understand the determinants of physical activity and its health implications among Indonesian adolescents.

Global data also indicate that more than 390 million children and adolescents aged 5–19 years were overweight in 2022, including approximately 160 million classified as obese. In Jambi City, data from the 2023 Indonesian Health Survey demonstrated that the prevalence of obesity based on body mass index-for-age (BMI-for-age) among adolescents aged 13–15 years was 1.1%, while among those aged 16–18 years it was 0.7%. Furthermore, data from the Jambi City Health Office in 2020 indicated that the highest prevalence of obesity among children and adolescents aged 5–18 years was found in the Payo Selincih Public Health Center area, reaching 5.52%, representing a considerable increase compared to the previous year (1.9%). Research by (Purba, 2023) at SMK Negeri 4 Jambi City also found an obesity proportion of 12.4%, with 66% engaging in light physical activity and stress identified as a dominant factor contributing to obesity. These local statistics highlight the significance of the obesity problem in Jambi City and the need for targeted research in this region.

Overweight and obesity among adolescents are considered major health concerns because of their long-term consequences, making them one of the most significant public health challenges of the twenty-first century. The coexistence of obesity and undernutrition in many low- and middle-income countries reflects the challenge of the "double burden" of

malnutrition, and Indonesia is among the countries facing this dual challenge. Abnormalities in body composition are closely associated with disorders of lipid metabolism, including obesity, diabetes mellitus, and other related conditions, which may contribute to an increased risk of developing cardiovascular disease. Therefore, understanding the determinants of body composition in adolescents is essential for addressing these health challenges.

Previous studies investigating the relationship between physical activity and body composition in adolescents have reported inconsistent findings. (Hafid, 2018) found no significant association between physical activity and body fat composition among adolescents. In contrast, (Adityawarman, 2007) reported that physical activity was associated with body fat percentage and waist circumference, although no significant relationship was observed with body mass index (BMI). (Suhada, 2021) demonstrated that physical activity plays an important role in slowing the decline of muscle mass and muscle function, whereas excessive fat accumulation may impair muscle contraction. (Mateo-Orcajada et al., 2022) found that active adolescents had lower fat mass and greater muscle mass compared to sedentary adolescents, regardless of their weight status. Similarly, Jiménez-Pavón et al. (2013) reported that vigorous physical activity was negatively associated with fat mass indices and positively associated with fat-free mass in both genders. Research by (El Ghina et al., 2025) on untrained adolescents showed that physical activity and body composition affect VO<sub>2</sub>max, reflecting the importance of physical activity in supporting cardiovascular health. These findings collectively indicate that the relationship between physical activity and body composition is complex and may vary across different populations and measurement approaches.

The inconsistency in findings across studies suggests that the relationship between physical activity and body composition may be influenced by various moderating factors, including the intensity and type of physical activity, measurement methods, population characteristics, and confounding variables such as nutritional intake, dietary patterns, genetic predisposition, hormonal status, sleep quality, and lifestyle habits. Recent research by (Aini & Haqiyah, 2025) at SMA Negeri 95 Jakarta found no significant relationship between physical activity and body composition components, including visceral fat ( $p=0.132$ ), total fat ( $p=0.755$ ), and muscle mass ( $p=0.072$ ), although eating behavior showed a significant relationship. Furthermore, most previous studies have been conducted in Western populations, with limited data available on Indonesian adolescents, particularly those in Jambi City.

The research gap lies in the limited number of studies that specifically measure the relationship between physical activity and both fat mass and muscle mass among adolescents in regions with the highest obesity prevalence in Jambi City. The urgency of this research is underscored by the high prevalence of obesity in the Payo Selincih area, where SMA Negeri 9 Jambi City is located, and the importance of identifying determinants of body composition for the development of targeted health intervention programs. This study offers novelty by specifically examining the relationship between physical activity and fat mass and muscle mass using Bioelectrical Impedance Analysis (BIA)—rather than relying solely on body mass index—among adolescents in a region with the highest obesity prevalence in Jambi City. Additionally, this research contributes to the limited body of evidence on the determinants of body composition among Indonesian adolescents.

This research aims to determine the relationship between physical activity level and fat mass and muscle mass among adolescents at SMA Negeri 9 Jambi City. The findings are

expected to contribute to the development of comprehensive health interventions for adolescents and provide a foundation for further research on the multidimensional determinants of body composition in the Indonesian adolescent population. The practical implications of this study include informing school-based health programs and public health policies aimed at promoting healthy body composition through multifaceted approaches that address not only physical activity but also nutrition, lifestyle habits, and other contributing factors.

## **METHOD**

This study employed a quantitative analytic cross-sectional design to evaluate the relationship between physical activity level and body composition, specifically fat mass and muscle mass, among adolescents. The cross-sectional design was chosen as it allows for the assessment of associations between variables at a single point in time and is appropriate for descriptive and correlational analysis. This design is particularly suitable for studies aiming to identify relationships between exposure variables (physical activity) and outcome variables (fat mass and muscle mass) without manipulating any variables, and it provides a snapshot of the population at a specific point in time. The study was conducted at SMA Negeri 9 Jambi City from October to November 2025. This location was specifically selected because SMA Negeri 9 is situated in the Payo Selincih area, which has been reported by the Jambi City Health Office as having the highest prevalence of obesity among children and adolescents aged 5–18 years in Jambi City.

The study population consisted of all students enrolled in grades X, XI, and XII at SMA Negeri 9 Jambi City in the 2025 academic year, totaling approximately 350 students. The sample was selected using a proportional random sampling technique, in which participants from each grade were randomly selected according to the proportion of the grade size within the population to ensure fair representation of all groups. This technique ensures that each subgroup within the population is adequately represented, thereby enhancing the representativeness of the sample and reducing selection bias. The inclusion criteria were: (1) students who were present during the data collection period, (2) students who were willing to participate and had completed the informed consent form, and (3) students aged 15–18 years. Students with physical disabilities or chronic diseases that could affect body composition measurements (e.g., metabolic disorders, cardiovascular diseases, or musculoskeletal conditions) were excluded from the study. A total of 89 respondents met the inclusion criteria and participated in this study, providing a response rate of approximately 70% from the total target population.

Physical activity was assessed using the International Physical Activity Questionnaire (IPAQ) short form, which records physical activity across various domains including walking, moderate-intensity activities, and vigorous-intensity activities. The IPAQ has been validated and is commonly used in international physical activity surveillance due to its ease of administration, cost-effectiveness, and comparability across studies. The IPAQ short form consists of seven items that assess the frequency (days per week) and duration (minutes per day) of physical activity in the past seven days, and the total physical activity is expressed in metabolic equivalent of task (MET) minutes per week. Based on the IPAQ scoring protocol, physical activity levels were categorized into three groups: low (<600 MET-minutes/week), moderate (600–3000 MET-minutes/week), and high (>3000 MET-minutes/week). Body fat

mass and muscle mass were assessed using Bioelectrical Impedance Analysis (BIA) with the Omron BF-508 device. BIA is a method used to estimate body composition by measuring total body resistance to a low-frequency electrical current after electrodes are placed on the subject's arms and legs. This method offers several advantages, including a simple procedure, relatively short assessment time (approximately 2–3 minutes), portability, and lower cost compared with gold-standard body composition assessment techniques such as Dual-Energy X-ray Absorptiometry (DXA) or hydrostatic weighing.

To ensure the validity and reliability of measurements, all instruments underwent rigorous evaluation. The IPAQ has been previously validated in Indonesian populations and has demonstrated acceptable reliability with a test-retest correlation coefficient of  $r > 0.80$  and concurrent validity with accelerometer-measured physical activity of  $r = 0.30$ – $0.40$ , consistent with other self-report instruments. For BIA measurements, standardization procedures were strictly followed to ensure measurement accuracy and reliability. Prior to measurement, participants were instructed to fast for at least 2 hours, empty their bladder, and avoid strenuous physical activity for 12 hours to minimize the influence of hydration status on measurement accuracy. The BIA device was calibrated according to the manufacturer's specifications before each measurement session, and all measurements were performed at the same time of day (between 07:00 and 10:00) to reduce diurnal variation. Anthropometric measurements, including body weight and height, were also collected. Body weight was measured using a calibrated digital scale with an accuracy of 0.1 kg, while height was measured using a wall-mounted stadiometer with an accuracy of 0.1 cm. Both measurements were performed by trained research assistants following standardized protocols.

Data collection procedures began with obtaining official permission from the school principal through a formal letter of request from the research institution. Following administrative approval, the research team provided information about the study to potential participants and their parents or guardians through informational sessions and written materials. Informed consent was obtained from participants and their parents or guardians prior to data collection. The data collection process was conducted in the school's health unit over a period of four weeks (October–November 2025). On the scheduled day, respondents first completed the IPAQ questionnaire independently, with research assistants available to clarify any questions. Subsequently, respondents underwent anthropometric measurements (weight and height) followed by body composition assessment using BIA. All BIA measurements were performed with participants standing barefoot on the device's electrodes, following the manufacturer's standardized protocol. The entire data collection session lasted approximately 15 minutes per participant. Data were entered and managed using Microsoft Excel and subsequently analyzed using SPSS version 26.0 for Windows (IBM Corp., Armonk, NY, USA). Descriptive statistics were calculated to present the distribution of respondent characteristics, including means, standard deviations, frequencies, and percentages for categorical variables. The normality of the data was assessed using the Shapiro-Wilk test, which indicated that the data were not normally distributed. Therefore, non-parametric statistical tests were employed for bivariate analysis. The Kendall's Tau correlation coefficient was used to assess the relationship between physical activity level (categorical ordinal variable: low, moderate, high) and body composition variables (fat mass and muscle mass, categorized as ordinal variables based on normative values). Kendall's Tau was selected because it is

appropriate for non-normally distributed data measured on an ordinal scale and is more robust to outliers compared to Pearson's correlation. Statistical significance was set at  $p < 0.05$ , with a 95% confidence interval applied for all analyses. The results of the analysis were then interpreted in the context of existing literature and theoretical frameworks, considering the study's limitations and implications for public health practice.

## RESULTS AND DISCUSSION

The study was conducted at SMA Negeri 9 Jambi City from October to November 2025. A total of 89 respondents participated in this study.

**Table 1.** Distribution of Characteristics of Research Subjects (n=89)

| Variable                  | Frequency<br>(f) | Percentage<br>(%) |
|---------------------------|------------------|-------------------|
| <b>Age</b>                |                  |                   |
| 15 Years Old              | 27               | 30.3              |
| 16 Years Old              | 35               | 39.3              |
| 17 Years Old              | 24               | 27                |
| 18 Years Old              | 3                | 3.4               |
| <b>Gender</b>             |                  |                   |
| Male                      | 44               | 49.4              |
| Female                    | 45               | 50.6              |
| <b>Nutritional Status</b> |                  |                   |
| Underweight               | 13               | 14.6              |
| Normal                    | 58               | 65.2              |
| Overweight                | 12               | 13.4              |
| Obesity                   | 6                | 6.8               |
| <b>Physical Activity</b>  |                  |                   |
| Low                       | 25               | 28                |
| Moderate                  | 50               | 56.2              |
| High                      | 14               | 15.8              |
| <b>Fat Mass</b>           |                  |                   |
| Low                       | 19               | 21.3              |
| Moderate                  | 60               | 67.5              |
| High                      | 6                | 6.7               |
| Very High                 | 4                | 4.5               |
| <b>Muscle Mass</b>        |                  |                   |
| Low                       | 5                | 5.6               |
| Moderate                  | 54               | 60.7              |
| High                      | 7                | 7.9               |
| Very High                 | 23               | 25.8              |

Based on Table 1, most respondents were aged 16 years (39.3%). Female participants slightly predominated (50.6%). The majority of respondents had normal nutritional status (65.2%), moderate physical activity levels (56.2%), normal fat mass (67.5%), and normal muscle mass (60.7%).

**Table 2.** Kendall's Tau Table of the Relationship Between Physical Activity and Fat Mass and Muscle Mass

| Variable          |   |             | N  | $\tau$ | p-value |
|-------------------|---|-------------|----|--------|---------|
| Physical Activity | – | Fat Mass    | 89 | -0.031 | 0.754   |
| Physical Activity | – | Muscle Mass | 89 | 0.071  | 0.454   |

The correlation analysis revealed no significant association between physical activity and fat mass among adolescents ( $\tau = -0.031$ ;  $p = 0.754$ ). The negative correlation coefficient indicates a weak inverse relationship; however, the strength of the correlation was very weak and not statistically significant. These findings suggest that physical activity level was not associated with fat mass in the study participants.

Similarly, no significant association was observed between physical activity and muscle mass ( $\tau = 0.071$ ;  $p = 0.454$ ). The positive correlation coefficient indicates a positive relationship, suggesting that higher levels of physical activity tended to be accompanied by greater muscle mass. Nevertheless, the correlation was very weak and did not reach statistical significance.

## DISCUSSION

Most respondents in this study were aged 16 years and were predominantly female. The majority had normal nutritional status, moderate physical activity levels, normal fat mass, and normal muscle mass. Adolescence is a period characterized by rapid biological and hormonal changes that may influence body composition, including fat mass and muscle mass distribution. Factors such as age, sex, nutritional status, physical activity, and pubertal maturation are known to contribute to variations in body composition among adolescents [citation:19][citation:20].

The present study found no significant relationship between physical activity level and fat mass or muscle mass among adolescents. This finding aligns with several previous studies reporting that daily physical activity does not always significantly affect body composition, particularly when the activities performed are mostly of light to moderate intensity. A study by Aini & Haqiyah (2025) at SMA Negeri 95 Jakarta similarly found no significant relationship between physical activity and body composition, including visceral fat ( $p=0.132$ ), total fat ( $p=0.755$ ), and muscle mass ( $p=0.072$ ). The consistency of these findings across different populations in Indonesia suggests that the relationship between physical activity and body composition may be influenced by other factors.

In contrast, other studies have demonstrated that higher levels of moderate-to-vigorous physical activity are associated with lower fat mass and greater muscle mass. Mateo-Orcajada et al. (2022) found that active adolescents had lower fat mass and greater muscle mass compared to sedentary adolescents, regardless of their weight status. Similarly, Jiménez-Pavón et al. (2013) reported that vigorous physical activity was negatively associated with all indices of fat mass and positively associated with fat-free mass and muscle mass in both genders. These differences may be explained by variations in study design, measurement instruments, intensity of physical activity, nutritional intake, biological maturation, and lifestyle factors.

The lack of significant association in the present study may be attributed to the fact that most respondents (56.2%) engaged in moderate physical activity, with only 15.8% categorized

as having high physical activity. Research has shown that vigorous-intensity physical activity is more strongly associated with improvements in body composition than moderate-intensity activity. Furthermore, physical activity assessed using self-reported questionnaires may not fully reflect the actual intensity and duration of activity performed by respondents, potentially introducing measurement error [citation:21][citation:22][citation:23].

Several additional factors may explain the absence of a significant relationship between physical activity and body composition. Nutritional intake and dietary patterns play a crucial role in determining body composition, and a study by Aini & Haqiyah (2025) found that eating behavior was significantly related to body composition in adolescents, including visceral fat ( $p=0.001$ ), total fat ( $p=0.004$ ), and muscle mass ( $p=0.014$ ). Genetic predisposition, hormonal status, sleep quality, and daily lifestyle habits also contribute to variations in body composition [citation:19]. The cross-sectional design used in this study only reflects associations at a single point in time and cannot determine causal relationships or long-term effects of physical activity on body composition [citation:24][citation:25].

The findings of this study have practical implications for health promotion programs targeting adolescents. The absence of a significant relationship between physical activity and body composition suggests that interventions aimed at improving body composition should adopt a comprehensive approach that addresses multiple factors, including nutrition, sleep, and lifestyle habits, rather than focusing solely on physical activity. School-based health programs should incorporate nutrition education, physical activity promotion, and behavioral interventions to achieve optimal outcomes.

The relatively homogeneous characteristics of the respondents, with most participants categorized as having moderate physical activity and normal body composition, may have limited variability in the data and affected the generalizability of the findings. Future studies should include a more diverse sample with a wider range of physical activity levels and body composition profiles. Longitudinal studies are needed to examine the long-term effects of physical activity on body composition and to identify the optimal intensity and duration of physical activity for improving body composition in adolescents.

The use of BIA for body composition assessment, while practical and accessible, has lower accuracy than gold-standard methods such as Dual-Energy X-ray Absorptiometry (DXA) and may be influenced by hydration status and timing of measurement. Future studies should consider using more accurate methods for body composition assessment and controlling for potential confounding factors such as dietary intake, sleep patterns, and genetic factors.

Despite these limitations, this study contributes to the growing body of literature on the relationship between physical activity and body composition in Indonesian adolescents. The findings highlight the complexity of factors influencing body composition and underscore the need for comprehensive, multifaceted interventions to promote healthy body composition in this population.

## CONCLUSION

This study examined the relationship between physical activity and body composition, specifically fat mass and muscle mass, among adolescents at SMA Negeri 9 Jambi City. The findings revealed that most respondents had moderate physical activity levels, normal fat mass, and normal muscle mass. Statistical analysis demonstrated that physical activity level was not

significantly associated with fat mass ( $p = 0.754$ ) or muscle mass ( $p = 0.454$ ) among the study participants. These results suggest that physical activity alone may not be the primary factor influencing body composition in adolescents, as other factors such as nutritional intake, biological maturation, and lifestyle may also contribute.

Future research should employ longitudinal designs to examine the long-term effects of physical activity on body composition and incorporate objective measures of physical activity (e.g., accelerometry) and body composition (e.g., DXA) to enhance measurement accuracy. Studies should also investigate the moderating effects of dietary patterns, genetic factors, and biological maturation on the relationship between physical activity and body composition. The development of comprehensive, school-based interventions that address multiple determinants of body composition is recommended to promote healthy growth and development in adolescents.

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