The Physical Activity-BMI Paradox: Unraveling Gender Disparities and Nutritional Status Complexities in SMK Muhammadiyah 2 Tangerang

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ABSTRACT

Background: *Urban adolescents in Indonesia face the dual challenges of epidemiological transition and the double burden of malnutrition. Although physical activity is a key determinant of health, the association with Body Mass Index (BMI) and nutritional status among vocational high school (SMK) students remains insufficiently explored, particularly using validated assessment tools. Therefore, this study aimed to examine the relationship between physical activity, BMI, and nutritional status.*
Method: *A cross-sectional study was conducted among 102 tenth-grade students (54 females, 48 males) aged 14–16 years at SMK Muhammadiyah 2 Tangerang. Respondents were recruited through convenience sampling, and physical activity was assessed using the validated Physical Activity Questionnaire for Adolescents (PAQ-A), categorized into three levels. BMI was calculated from standardized anthropometric measurements. In addition, data were analyzed using Chi-square tests, One-Way ANOVA, and Spearman correlation (α=0.05).*
Result: *The results showed that approximately 83.3% of adolescents were insufficiently active. A significant gender gap was identified, with males remarkably more inclined to be active (70.6% of the active group, p=0.004). Contrary to conventional expectations, no significant association was found between physical activity levels and BMI (p=0.631) or categorical nutritional status (p=0.279). The highest prevalence of normal nutritional status was paradoxically observed in the moderately active, not the most active, group (72.7%). It indicates the need for a paradigm shift in adolescent health promotion from a weight-centric physical activity agenda to gender-sensitive, holistic interventions aimed at overall well-being, recognizing that the benefits may not be directly visible in short-term anthropometric measures.*

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INTRODUCTION

The global rise in sedentary lifestyles among adolescents, accelerated by technological advances and increasing screen-based activities, has substantially elevated the worldwide risk of obesity and metabolic disorders.(1) The World Health Organization (WHO) documents a parallel increase in adolescent obesity rates alongside declining physical activity levels, with approximately 80% of adolescents globally failing to meet the recommendation of 60 minutes of moderate-to-vigorous physical activity daily.(1) In Indonesia, this trend is of particular concern, with the 2023 Indonesian Health Survey showing an alarming statistic, indicating that the prevalence of overweight and obesity among adolescents aged 15-18 in Banten Province reached 10.5%.(2) This figure substantially exceeds the national mean for comparable age groups, suggesting a critical regional health challenge. Rapid urbanization in areas such as Tangerang City, located within the greater Jakarta metropolitan region, is associated with profound lifestyle transformations characterized by increased consumption of energy-dense processed foods and a marked decline in physical activity among adolescents.(3)

The Indonesian Ministry of Health has prioritized adolescent health within the 2025 National Health Strategy, explicitly targeting the double burden of malnutrition where undernutrition coexists with rising rates of overweight and obesity (4). Within this framework, vocational high schools (SMK), such as SMK Muhammadiyah 2 Tangerang, represent a significant study setting. Students in vocational tracks face unique challenges, including prolonged sedentary periods during practical training sessions and academic activities.(5) In general, Body Mass Index (BMI) remains a primary indicator for assessing nutritional status in school-based health initiatives. Although international studies have shown that structured physical activity interventions can significantly reduce BMI in children and adolescents with obesity,(6) the relationship between habitual physical activity and BMI within Indonesia unique socio-cultural context remains insufficiently explored. Specifically, it is uncertain whether variations in habitual physical activity translate into measurable differences in BMI and nutritional status. This is especially true for studies employing validated measurement instruments in under-explored populations such as vocational students.

Gender disparities represent a critical but often underexplored dimension in adolescent health studies. Globally, female adolescents consistently report lower levels of physical activity compared to males, influenced by socio-cultural norms, safety concerns, and differential access to recreational opportunities.(7)(8) These disparities may contribute to differences in body composition, metabolic risk, and nutritional status across sexes. Although insufficient physical activity has been associated with increased adiposity and cardiometabolic vulnerability,(9)(10)new evidence suggests that the relationship between physical activity and BMI is not always linear and may differ by gender due to variations in hormonal regulation, fat distribution patterns, and behavioral compensatory mechanisms.(11) In the Indonesian context, where the double burden of malnutrition persists,(9)(10) gender-based differences in activity patterns may intersect with dietary behaviors and socioeconomic factors, potentially shaping distinct nutritional outcomes among male and female adolescents.

Existing local studies investigating this association using standardized tools are limited. A preliminary investigation in Jakarta using the Physical Activity Questionnaire for Adolescents (PAQ-A) reported that 68.3% of adolescents showed low physical activity levels. However, the study did not comprehensively explore the connection with nutritional status.(12) This indicates a critical evidence gap for Indonesian adolescent health policy, particularly within the vocational education context. Based on the energy balance framework and international literature,(9)(10) it was hypothesized that higher levels of physical activity would be associated with lower BMI values and a greater probability of normal nutritional status. Additionally, gender differences are expected to significantly influence physical activity patterns and potentially moderate the association between physical activity and BMI. Therefore, this study aimed to analyze the association between physical activity levels, BMI, and nutritional status as well as gender disparities within the relationship. The results are intended to inform evidence-based, gender-sensitive school health policies that extend beyond a purely weight-centric approach.

METHOD

Study design and setting

This study used an observational cross-sectional design conducted between January and March 2025 among tenth-grade students at SMK Muhammadiyah 2 Tangerang, a private urban vocational high school, offering technical and business-oriented tracks. Students participate in predominantly classroom-based academic instruction combined with skill-based practical sessions, potentially resulting in mixed sedentary and active activity patterns. The cross-sectional design was selected to examine the relationship between physical activity, BMI, and nutritional status at a single time point using a descriptive-analytic quantitative approach. The school setting was selected to provide access to a defined population of urban vocational adolescents.

Population, sample, and sampling technique

The target population comprised all first-grade SMK students aged 14–16 years in urban Tangerang City. The accessible population included all tenth-grade students enrolled at SMK Muhammadiyah 2 Tangerang. Inclusion criteria were (1) age 14–16 years, (2) willingness to participate by providing written informed consent (and assent from parents/guardians), and (3) absence of any medical condition limiting anthropometric measurement. Meanwhile, exclusion criteria were (1) individuals with permanent physical disabilities, and (2) those taking medication known to affect body weight or metabolism. A convenience sampling technique was used due to administrative feasibility and the need to ensure complete anthropometric and questionnaire data collection within a limited school-based timeframe. The minimum sample size was calculated using the Lemeshow formula for proportion estimation. With a 95% confidence level (Z=1.96), an assumed prevalence of 0.5, and a precision of 0.1, the minimum required sample was 96 respondents. After accounting for a potential 10% dropout rate, the study recruited 102 eligible respondents.

Variables and measurement

The primary independent variable was physical activity, measured using the validated Indonesian short version of the PAQ-A. Physical activity was classified into three categories based on WHO recommendations, namely (1) Inactive, (2) Low Active, and (3) Active. The dependent variables were BMI and nutritional status. BMI was calculated as weight in kilograms divided by height in meters squared (kg/m²). Anthropometric measurements were performed by trained enumerators using standardized WHO protocols with a calibrated digital Seca scale (accuracy 0.1 kg) and a Seca stadiometer (accuracy 0.1 cm). In addition, nutritional status was classified according to the Indonesian Ministry of Health standards into underweight (BMI <18.5), normal (BMI 18.5–24.9), overweight (BMI 25–29.9), and obese (BMI ≥30). Gender (a control variable) was categorized as male or female based on self-reported identity.

Data collection procedure

Anthropometric measurements followed a standardized protocol. Each measurement was conducted twice, and the mean value was recorded. Body weight was measured using a calibrated SECA 813 digital scale (precision 0.1 kg), with respondents wearing light clothing and no shoes, while height was assessed using a portable SECA 213 stadiometer (precision 0.1 cm). BMI was calculated using the standard formula (kg/m²) and classified according to WHO age- and sex-specific criteria for adolescents (13). Physical activity was assessed using the validated Indonesian version of the PAQ-A, which has a reported reliability coefficient of Cronbach's $\alpha = 0.82$ (13). This questionnaire evaluates physical activity patterns across various domains over the previous seven days, yielding a continuous score from 1 (low activity) to 5 (high activity). The PAQ-A questionnaire was self-administered under supervision to minimize peer influence and ensure completeness. Enumerators were trained before data collection to standardize measurement techniques and reduce inter-observer variability.

Statistical analysis

Data analysis was performed using IBM SPSS Statistics version 26.0, with a significance level set at $\alpha=0.05$. Descriptive analysis presented normally distributed continuous, non-normally distributed continuous, and categorical data as mean ± standard deviation (SD), median (range), and frequency (percentage), respectively.

Normality was tested using the Kolmogorov-Smirnov test for $n \geq 50$. Bivariate analysis included (1) Chi-square test with Yates' correction to analyze the association between physical activity, gender, nutritional status, and Cramer's V as the effect size, (2) One-Way ANOVA to compare mean BMI across physical activity categories, after checking assumptions of residual normality and homogeneity of variance (Levene's test), with eta squared (η^2) as the effect size, and (3) Spearman's rank correlation coefficient (ρ) to analyze correlations involving ordinal and continuous variables.

RESULT AND DISCUSSION

This study recruited 102 respondents with a balanced gender distribution of 54 females (52.9%) and 48 males (47.1%), as shown in Table 1. The anthropometric profile showed a median body weight of 55.5 kg (range 33–90 kg), a median height of 1.64 m (range 1.50–1.78 m), and the mean BMI was 21.05 ± 4.87 kg/m². According to the BMI classification, the majority of respondents, namely 65 individuals (63.7%), showed normal nutritional status. However, collectively, 37 respondents (36.3%) fell outside the normal range, comprising 14 underweight individuals (13.7%), 14 overweight (13.7%), and 9 obese (8.8%). Regarding physical activity, most respondents (53.9%) engaged in moderate-intensity activity, followed by low (29.4%) and high (16.7%) levels (Table 1).

The result showing that the majority of the sample had a normal nutritional status according to WHO standards is a positive indicator (13). However, the prevalence of abnormal nutritional status affecting over one-third of the population, with nearly equal proportions of underweight and overweight/obesity, suggests the presence of a double burden of malnutrition (14).

This phenomenon, where undernutrition and overnutrition coexist within the same population, is increasingly common in many developing countries and presents a complex challenge for health systems (15). The wide variation in body weight and the large standard deviation of BMI (4.87) reflect considerable socio-demographic and lifestyle diversity within the study sample.

Table 1. Characteristics of respondents

Variable	Results (n=102)	
	Mean ± SD	Median (Min-Max)
Gender		
Female	54 (52.9)	
Male	48 (47.1)	
Body Weight (kg)		55.5 (33-90)
Body Height (m)		1.64 (1.50-1.78)
Body Mass Index (BMI) [kg/m^2]	21.05±4.87	
Nutritional Status [n (%)]		
Underweight (<16,5)	14 (13.7)	
Normal (16,5-23)	65 (63.7)	
Overweight (24-28)	14 (13.7)	
Obese (>28)	9 (8.8)	
Physical Activity [n (%)]		
Low	30 (29.4)	
Moderate	55 (53.9)	
High	17 (16.7)	

Collectively, these results indicate the need for differentiated public health interventions. General nutrition and physical activity promotion should be complemented by targeted approaches. For the underweight group, efforts should focus on improving the quality and quantity of energy and protein intake.(18) Conversely, for overweight/obese and inactive individuals, interventions should emphasize creating an energy deficit through balanced diets and gradual increases in physical activity, such as by reducing sedentary behavior and enhancing daily movement.(19–29) Education on weight monitoring and the importance of maintaining an active lifestyle is also crucial for primary prevention.(21)

Association of physical activity levels with gender, bmi, and nutritional status

A comparative analysis across physical activity levels showed significant variations in gender distribution and anthropometric profiles as presented in Table 2. A statistically significant association was found between gender and physical activity level ($p = 0.004$, Cramer's V = 0.332). Females were disproportionately represented in the low-activity group (76.7% of that group), while males constituted the majority in the moderate-activity (52.7%) and high-activity (70.6%) groups.

Conversely, no statistically significant differences were observed in BMI or nutritional status distribution across the activity categories. The mean BMI showed a non-significant increasing trend from low (20.36 ± 5.26 kg/m²) to moderate (21.26 ± 4.23 kg/m²) and high activity (22.61 ± 6.12 kg/m²), but the One-Way ANOVA test was not significant ($p = 0.631$, $\eta^2 = 0.009$), indicating minimal effect size. The distribution of nutritional status categories (underweight, normal, overweight, and obese) across activity levels also showed no significant association ($p = 0.279$, Cramer's V = 0.191), although descriptive patterns were evident. For instance, underweight prevalence was highest in the low-activity group (23.4%), while the moderate-activity group had the highest proportion of normal nutritional status (72.7%) and the lowest proportion of obesity (5.5%).(Table 2)

The strong and significant association between gender and physical activity level is consistent with a substantial body of global evidence. Studies consistently report that females, particularly in certain cultural or regional contexts, are more inclined to engage in lower levels of leisure-time and transport-related physical activity due to a complex interplay of socio-cultural norms, safety concerns, domestic responsibilities, and access to recreational facilities.(8–22) The high female representation in the low-activity subgroup indicates the critical need for gender-sensitive public health strategies that address these specific barriers to promote equitable participation in physical activity.

Table 2. Characteristics of respondents stratified by physical activity level (n=102)

Characteristic	Low Physical Activity (n=30)	Moderate Physical Activity (n=55)	High Physical Activity (n=17)	Total (N=102)	P-value	Effect Size
Gender, n (%)						
Female	23 (76.7)	26 (47.3)	5 (29.4)	54 (52.9)	**Chi-Square = 0,004**	**Cramer's V = 0,332**
Male	7 (23.3)	29 (52.7)	12 (70.6)	48 (47.1)		
Body Mass Index (kg/m²)						
Mean ± SD	20.36 ± 5.26	21.26 ± 4.23	22.61 ± 6.12	21.05 ± 4.87	One-Way ANOVA = 0.631	η^2 = 0.009
95% CI	(18.39 – 22.32)	(20.11 – 22.40	(18.46 – 24.76	(20.09 – 22.01		
Range	14,11-30.49	15.06-35.52	12,12-36.51	12.12-36.51		
Nutritional Status, n (%)						
Underweight (<16,5)	7 (23.4)	4 (7.3)	3 (17.6)	14 (13.7)	Chi-Square = 0.279	Cramer's V = 0.191
Normal (16,5-23)	16 (53.3)	40 (72.7)	9 (52.9)	65 (63.8)		
Overweight (24-28)	3 (10.0)	8 (14.5)	3 (17.6)	14 (13.7)		
Obese (>28)	4 (13.3)	3 (5.5)	2 (11.9)	9 (8.8)		

The absence of a significant linear relationship between physical activity level and BMI in this cross-sectional analysis is an important result. It suggests that within this specific sample, activity level alone may not be the primary determinant of current body weight, a result supported by other studies underscoring the multifactorial nature of energy balance.(9)(10) The observed numerical trend of higher mean BMI with higher activity level could be influenced by factors such as increased muscle mass in the highly active group or reflect a small sample size limitation in the high-activity category (n=17), reducing statistical power. Similar patterns have also been observed in Indonesian adolescent populations.

A school-based study in Jakarta reported no significant association between self-reported physical activity levels and BMI among high school students, suggesting that variations in activity did not directly translate into measurable differences in BMI (16). National surveillance data from the Indonesian Health Survey similarly emphasize prevalence estimates of inactivity and overweight but do not consistently demonstrate a clear linear association between the two variables.(2)

The complex interplay between physical activity and body composition may also be influenced by patterns of energy intake and metabolic compensation, especially in adolescent populations. In Indonesian adolescents, studies have shown that physical activity alone does not always correspond with BMI or nutritional status because energy balance is modulated by dietary energy intake and lifestyle behaviors. For example, a cross-sectional study among junior high school students in East Kalimantan found that both physical activity and total energy intake were significantly correlated with nutritional status, indicating higher activity levels may be offset by higher energy consumption or other compensatory behaviors affecting body weight outcomes.(23)

Moreover, studies on Indonesian vocational students reported that variations in physical activity did not consistently predict BMI, suggesting non-exercise activity, dietary practices, and socioenvironmental factors may diminish the expected impact of activity on weight status.(24) These results are consistent with the literature emphasizing that physical activity effects on BMI are subject to energy compensation mechanisms, potentially blunting the associations in cross-sectional studies.

The descriptive pattern in nutritional status is insightful for program planning. The concentration of underweight individuals in the low-activity group may indicate a cluster of energy deficiency and lethargy, possibly related to underlying health issues, inadequate nutrition, or socioeconomic constraints.(18) The favorable profile of the moderate-activity group, having the highest normal weight prevalence and lowest obesity rate, reinforces the protective role of regular, sustained activity as recommended in global guidelines.(20) This group may represent individuals who have successfully integrated consistent, manageable activity into daily routines, yielding optimal metabolic benefits without the potential compensatory behaviors (e.g., increased caloric intake) sometimes associated with high-intensity exercise regimens .(11)

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Table 3. Correlation analysis between physical activity, gender, BMI, and nutritional status

Variable	Coefficient Correlation (ρ)	P-value
Physical Activity – Gender	0.332[a]	0.004
Physical Activity – BMI	0.156[b]	0.118
Physical Activity – Nutritional Status	0.271[a]	0.279

Notes: a. Phi; b. Spearman's rho

Correlation analysis of physical activity with gender, bmi, and nutritional status

Formal correlation analysis was conducted to quantify the relationships between physical activity levels and key variables (Table 3). The analysis confirmed a statistically significant, weak-to-moderate positive correlation between physical activity and gender ($\rho = 0.332$, $p = 0.004$), using coding where male gender was associated with higher activity levels. In contrast, no statistically significant correlation was found between physical activity and BMI ($\rho = 0.156$, $p = 0.118$) or between physical activity and nutritional status ($\rho = 0.271$, $p = 0.279$).

The correlation results provide a precise statistical confirmation of the patterns observed in the comparative analysis.

The significant correlation with gender ($\rho = 0.332$) reinforces the substantive gender disparity in physical activity levels within this population. This effect size, categorized as moderate, suggests that gender explains a meaningful portion of the variance in physical activity behavior. The result is consistent with socio-ecological models of health behavior, showing that gender roles and norms act as powerful interpersonal and community-level factors influencing activity choices.(25)(26) The correlation indicates that promoting physical activity is not a gender-neutral endeavor and must account for the different lived experiences and constraints faced by males and females.

The non-significant correlation between physical activity and BMI ($\rho = 0.156$, $p = 0.118$) indicates a negligible linear relationship within the sample. This lack of a strong direct correlation is consistent with complex models of energy homeostasis, where physical activity is one of many interdependent components, including dietary intake, basal metabolic rate, and physiological adaptations.(9–27) It suggests that for many individuals, changes in physical activity may be offset by compensatory mechanisms in other parts of the energy balance equation, thereby blunting the isolated effect on BMI in a cross-sectional snapshot.(11)

The non-significant correlation with nutritional status ($\rho = 0.271$, $p = 0.279$), despite a coefficient suggesting a weak positive trend, also indicates that the ordered categories of nutritional status (underweight to obese) do not linearly correlate with higher activity levels in a statistically significant manner. This could be due to the non-linear relationship between activity and body composition. For example, both underweight and obese individuals may be inactive for different reasons (e.g., illness vs. functional limitation), while normal-weight individuals may show a wide range of activity levels(9)(28)

Integrated Implications and Recommendations

The comparative and correlational analyses show that gender is a key correlate of physical activity level, while current BMI and nutritional status show no significant linear association. This has direct implications for public health strategy, first, interventions aiming to increase population activity levels must be gender-transformative, actively engaging females and addressing the specific cultural, social, and environmental barriers.(8–29) Second, the absence of a significant association between physical activity and BMI suggests that school health policies should avoid positioning physical activity solely as a short-term weight-control intervention. Instead, physical activity promotion should be framed within a broader health paradigm that emphasizes cardiometabolic fitness, psychological well-being, and functional capacity, independent of immediate anthropometric changes.(30) Effective programs should integrate physical activity promotion with parallel support for sustainable dietary change to address nutritional status more holistically.(31) From a policy perspective, these results caution against overreliance on BMI as the primary outcome indicator for evaluating school-based physical activity programs and indicate the need for multidimensional health metrics.

Despite the significant results, several limitations must be acknowledged. The cross-sectional design precludes causal inference and limits the ability to capture temporal adaptations between physical activity and body composition. The use of convenience sampling within a single vocational school may restrict external generalizability to other adolescent populations. Additionally, physical activity was assessed through self-reported PAQ-A, which may introduce recall bias and measurement error. BMI also does not distinguish between fat mass and lean mass, potentially obscuring body composition differences. Future studies should adopt longitudinal or cohort designs to clarify causal pathways, incorporate objective activity measurements such as accelerometry, and use more precise indicators of body composition (e.g., bioelectrical impedance or DXA). Expanding samples across multiple vocational schools and incorporating dietary intake assessments would further elucidate the interaction between energy intake, expenditure, and nutritional status within Indonesia double burden context(32)

CONCLUSION

In conclusion, this study shows a nuanced perspective on health dynamics among adolescents at SMK Muhammadiyah 2 Tangerang by demonstrating a critical dissociation. Although a significant gender gap in physical activity levels persists, with females disproportionately inactive, no direct linear association was found between physical activity and current BMI or nutritional status. These results directly address the study objectives by demonstrating that although gender disparities in activity patterns are evident, variations in physical activity levels were not significantly associated with anthropometric outcomes. Importantly, the absence of a significant association does not negate the health value of physical activity but rather indicates the multifactorial nature of energy balance, where dietary intake, metabolic adaptation, body composition differences, and environmental influences may attenuate observable BMI changes in cross-sectional analysis. The results underscore the necessity for dual-focused public health approaches of implementing gender-sensitive interventions to overcome activity barriers while delivering targeted nutritional strategies to address the distinct etiologies of undernutrition and overnutrition coexisting within the same population.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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