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Nutritions, Exercise, and Musculoskeletal Fitness in Strada Santa Anna Junior High School Students

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ABSTRACT

This study aimed to describe the level of musculoskeletal fitness among junior high school students at SMP Strada Santa Anna, East Jakarta, and to analyze its association with physical activity, muscle strength training, nutritional status (BMI-for-age), and macronutrient intake (energy, carbohydrates, protein, and fat). A total of 111 eighth-grade students participated in this cross-sectional study. Data were collected through interviews using the 2x24-hour food recall, the Physical Activity Questionnaire for Children (PAQ-C), the Muscle-Strengthening Exercise Questionnaire Short Form (MSEQ-short), and anthropometric measurements. Musculoskeletal fitness was assessed by using the Standing Long Jump (SLJ) test, with an average score of 151.43 ± 36.92 cm. Male students scored significantly higher than female students. Musculoskeletal fitness was significantly associated with sex, physical activity, energy intake, carbohydrate intake, and protein intake. No significant association was found with BMI-for-age and fat intake. Among all variables, physical activity showed the strongest correlation. The findings emphasize the importance of promoting healthy habits, such as balanced macronutrient intake and regular anaerobic physical activity. School-based interventions, including nutrition education and lifestyle promotion, are essential to support the improvement of adolescent musculoskeletal fitness.

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INTRODUCTION

Over the past two decades, global studies have reported a declining trend in musculoskeletal fitness among adolescents across various countries (Tomkinson et al., 2021). Musculoskeletal fitness is recognized as a general health biomarker in adolescents (García-Hermoso et al., 2019). Its benefits include injury prevention, improved bone health, regulation of body mass index, and optimization of cardiovascular, cardiorespiratory, and metabolic functions in children and adolescents (Stodden & Brooks, 2013).

Adolescence represents a critical period for musculoskeletal development due to the occurrence of growth spurts during puberty, which significantly contribute to increases in bone density and muscle mass (Vicente-Rodríguez, 2006). Lower limb musculoskeletal fitness plays a vital role in supporting body weight and facilitating daily activities such as standing, walking, and jumping, as well as in maintaining posture and balance and preventing musculoskeletal disorders, including scoliosis and knee injuries (Kell et al., 2001). One practical and time-efficient method for assessing musculoskeletal fitness is the Standing Long Jump (SLJ) test, which is widely used to evaluate muscle fitness in children at the population level (Paineau et al., 2008; Rodríguez et al., 2005; Ruiz et al., 2008).

In several countries, musculoskeletal fitness assessed using the SLJ test has shown a declining trend, including in Australia (Tomkinson et al., 2021) and Spain (2006–2007) (Moliner-Urdiales et al., 2010). Similar patterns have also been reported in other countries (Cohen et al., 2011; Runhaar et al., 2010). A preliminary study conducted in East Jakarta reported average SLJ scores of 183.21 ± 20.35 cm for boys and 153.63 ± 18.72 cm for girls (Febriana, 2025). When compared with findings from a study involving Grade VII–XI students in China, in which boys averaged 192.05 ± 27.25 cm and girls averaged 158.36 ± 20.20 cm (Zhu et al., 2017), the average SLJ scores in Jakarta remain relatively low.

Several factors influence musculoskeletal fitness, including sex, body mass index for age (BMI-for-age), nutritional intake, physical activity, and strength training. According to Chung et al. (2013), boys consistently outperform girls in SLJ performance across all age groups, likely due to greater increases in steroid hormones, growth hormone, and bone mineral content during puberty. In addition, BMI-for-age has been shown to be associated with SLJ performance, with individuals who have a normal BMI generally achieving better results (Chen et al., 2022). Other studies have reported a negative relationship between BMI and musculoskeletal fitness, as well as positive associations between energy, protein, and fat intake and fitness levels (Primadiyanti et al., 2019). Furthermore, physical activity and muscle-strengthening exercise are essential for improving musculoskeletal fitness (de Salles Painelli, 2023; Mačak et al., 2022).

In Indonesia, limited research has examined the relationship between musculoskeletal fitness and nutritional intake. Balanced nutrition, particularly adequate energy intake, plays a crucial role in supporting growth, physical performance, and recovery during adolescence (Wen et al., 2005). This developmental stage is also critical for musculoskeletal health and serves as an indicator of general health, cardiovascular health, bone metabolism (Smith et al., 2014), neuromotor development (Häger-Ross & Rösblad, 2002), and long-term well-being (García-Hermoso et al., 2019). Based on preliminary findings in East Jakarta, which revealed lower average SLJ scores compared to those reported in other countries, as well as considerations of feasibility and the limited availability of similar studies, SMP Strada Santa Anna in East Jakarta was selected as the study site to explore adolescent musculoskeletal fitness. This study aims to contribute local evidence and serve as a foundation for planning

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fitness interventions and health promotion programs targeting children and adolescents in school settings.

METHODS

Research Design

This study employed a quantitative cross-sectional design involving 111 eighth-grade students (57 boys and 54 girls) to examine the associations between the independent and dependent variables at a single point in time. Musculoskeletal fitness was designated as the dependent variable, while the independent variables included energy intake, carbohydrate intake, protein intake, fat intake, body mass index-for-age (BMI-for-age), physical activity, muscle-strengthening exercise, and sex. The study was conducted from March to April 2025 among eighth-grade students at SMP Strada Santa Anna, East Jakarta.

Participants

The study population comprised all actively enrolled eighth-grade students at SMP Strada Santa Anna during the 2024/2025 academic year. The inclusion criteria were students aged 12–14 years, actively enrolled, physically healthy, and without physical disabilities that could interfere with the performance of the Standing Long Jump (SLJ) test, such as lower limb impairments, muscle or nerve disorders, spinal conditions, or other mobility-limiting disorders. The exclusion criteria included professional athletes and students with lower extremity health conditions that could prevent them from safely performing the SLJ test.

Sampling Procedures

Participants were selected using purposive sampling, adjusted to physical education class schedules. Initially, 141 students from four eighth-grade classes at SMP Strada Santa Anna were recruited. Of these, 30 students were excluded due to absence on the day of data collection, non-completion of the second 24-hour food recall, refusal to complete questionnaires, the presence of a medical condition (Type II Diabetes Mellitus), or identification as outliers based on anthropometric analysis. Consequently, the final sample consisted of 111 students.

Materials and Apparatus

Several instruments were used to assess the study variables. Data collection was conducted using a structured research questionnaire that included informed consent, demographic information, SLJ test results, anthropometric measurements, physical activity assessment (modified Physical Activity Questionnaire for Children/PAQ-C), muscle-strengthening exercise assessment (modified Muscle-Strengthening Exercise Questionnaire Short Form/MSEQ-short), and two 24-hour food recalls. Anthropometric measurements were obtained using a digital weighing scale with an accuracy of 0.1 kg and a microtoise with an accuracy of 0.1 cm. The SLJ test was conducted using a 5-meter measuring tape, cones, and adhesive tape. Additional materials included standard stationery.

Research Procedures

Data collection was carried out during physical education class hours. Participants were first gathered and provided with an explanation of the study procedures, after which informed consent forms were obtained to ensure confidentiality and confirm that the data would be used solely for research purposes. Participants then completed demographic and physical activity questionnaires. Physical activity was assessed using the Physical Activity Questionnaire for Older Children (PAQ-C), while muscle-strengthening exercise was measured using the Muscle-Strengthening Exercise Questionnaire Short Form (MSEQ-short). PAQ-C scores were calculated by summing item responses, whereas MSEQ-short scores were obtained by multiplying the frequency of exercise (days per week) by the average duration per session (minutes) to yield total minutes per week.

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Anthropometric measurements were subsequently conducted using a digital scale and microtoise. Body mass index-for-age (BMI-for-age) was calculated, and z-scores were analyzed using WHO AnthroPlus software. Musculoskeletal fitness was assessed using the Standing Long Jump (SLJ) test. Prior to testing, participants completed a readiness form to ensure safety. Finally, a 2 × 24-hour food recall was administered by trained enumerators, covering one weekday and one weekend day, to capture dietary variability and minimize recall bias.

Data Analysis

Normality tests were conducted using the Kolmogorov–Smirnov test in SPSS version 22. As the data were normally distributed, independent sample t-tests were used to analyze relationships between categorical and numerical variables. For relationships between numerical variables, correlation analyses and simple linear regression analyses were performed.

RESULTS

A total of 111 students participated in the study, consisting of 57 boys and 54 girls. The majority of students at SMP Strada Santa Anna were classified as having a normal nutritional status (65.8%), while 18.9% were overweight and 9.9% were obese. Additionally, 5.4% of students were classified as undernourished, and and no cases of severe malnutrition were identified (Table 1).

Based on participation in muscle-strengthening exercise, students were categorized into two groups: those who reported engaging in muscle-strengthening exercise (n = 49) and those who did not (n = 62), as presented in Table 1.

The average musculoskeletal fitness level, measured using the Standing Long Jump (SLJ) test, was 151.43 ± 36.92 cm. Boys demonstrated a higher mean SLJ score (175.28 ± 32.67 cm) compared with girls (126.25 ± 21.08 cm). According to the established fitness classification, both values fell within the “average” category of musculoskeletal fitness (Table 2).

The average daily energy intake for both boys and girls was below the Indonesian Recommended Dietary Allowance (AKG) (Kemenkes RI, 2019). Boys consumed an average of 1632.87 kcal (68% of AKG), while girls consumed 1483.27 kcal (72% of AKG). Similarly, average carbohydrate intake did not meet the recommended levels, with boys consuming 219.28 g (62% of AKG) and girls 196.46 g (65% of AKG). In contrast, average protein intake met recommended levels for both boys (60.91 g; 87% of AKG) and girls (54.55 g; 83% of AKG). Fat intake remained below recommendations in both groups, with boys consuming 55.64 g (69% of AKG) and girls 52.47 g (74% of AKG) (Table 2).

The average BMI-for-age z-score was 0.26 ± 1.27, indicating a general classification of normal nutritional status, as the score fell within the range of -2 SD to +1 SD. The median PAQ-C score was 2.23, reflecting a generally low level of physical activity among students (Table 2).

Among students who reported participating in muscle-strengthening exercise (n = 49), the mean total duration was 110 ± 108 minutes per week. This duration was below the World Health Organization (WHO, 2020) recommendation of at least 180 minutes per week, equivalent to approximately three days of activity per week (Table 2).

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Table 1. Univariate Analysis of Categorical Data among Students of SMP Strada Santa Anna, East Jakarta, 2025 (n= 111)

Variable	Frequency (n)	Percentage (%)
Sex		
Male	57	51,4
Female	54	48,6
BMI/A		
Severely Thin	0	0
Thin	6	5,4
Normal Weight	73	65,8
Overweight	21	18,9
Obesity	11	9,9
Muscle Strengthening Exercise		
Yes	49	44,14
No	62	55,8

Table 2. Univariate Analysis of Numerical Data among Students of SMP Strada Santa Anna, East Jakarta, 2025

Variable	n	Mean ± SD	Median	Min - Max
Musculoskeletal Fitness (cm)	111	151,43 ± 36,92	145	78,5 - 234,5
Male		175,28 ± 32,67	175,5	99,5 - 234,5
Female		126,25 ± 21,08	128	78,5 - 169
BMI/A (*z-score)*	111	0,26 ± 1,27	0,3	-2,61 - 2,57
Physical Activity (PAQ-C score)	111	2,34 ± 0,59	2,23	1,34 - 3,83
Energy Intake (kkal)	**111**	1560 ± 477,09	1502,45	604 - 2893
Male		1632,87 ± 454,2	1570,15	604 - 2893
Female		1483,27 ± 492,68	1372,57	715 - 2708
Carbohydrate Intake (gr)	**111**	208,18 ± 67	203,35	69 - 383
Male		219,28 ± 64,41	211,65	69 - 383
Female		196,46 ± 68,28	189,95	96 - 346
Protein Intake (gr)	**111**	57,81 ± 20,32	57,2	18 - 113
Male		60,91 ± 19,86	61,05	22 - 102
Female		54,55 ± 20,46	50,7	18 - 113
Fat Intake (gr)	**111**	54,1 ± 20,36	52,25	20 - 110
Male		55,64 ± 20,8	52,25	20 - 110
Female		52,47 ± 19,95	51,55	23 - 106
Muscle Strengthening Exercise (minutes/week)	**49**	110 ± 108	67,5	10 - 480
Muscle Strengthening Exercise (days/week)	**49**	3,04 ± 1,52	3	1 - 7

The average musculoskeletal fitness score among students who engaged in muscle strength training was 36.32 cm higher than that of students who did not. An independent samples t-test showed a significant difference in musculoskeletal fitness between students who performed strength training and those who did not (Table 3).

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Table 3. Analysis of Musculoskeletal Fitness by Muscle Strength Training Participation among Students of SMP Strada Santa Anna, East Jakarta, 2025 (n = 111)

Variable	Muscle Strength Exercise	N	Mean ± SD	*P value*
Musculos keletal Fitness (SLJ)	Yes	49	171,71 ± 38,26	0,001*
	No	62	135,39 ± 26,74	

Physical activity, energy intake, carbohydrate intake, and protein intake were found to be significantly and positively associated with musculoskeletal fitness. In contrast, BMI-for-age (BMI/A) and fat intake did not show a significant relationship (Table 4).

Table 4. Correlation Analysis between Musculoskeletal Fitness and Numerical Variables among Students of SMP Strada Santa Anna, East Jakarta, 2025 (n = 111)

Variable	Correlation (r)	R^2	P value
BMI/A (*z-score)*	-0,167	0,028	0,08
Physical Activity (PAQ-C score)	0,433	0,187	0,001*
Energy Intake (kkal)	0,214	0,046	0,024*
Carbohydrate Intake (gr)	0,254	0,064	0,007*
Protein Intake (gr)	0,189	0,036	0,046*
Fat Intake (gr)	0,103	0,011	0,283

DISCUSSION

Musculoskeletal fitness is a key health biomarker in children and adolescents. In this study, musculoskeletal fitness was assessed using the Standing Long Jump (SLJ) test, as it is a practical, time-efficient, and cost-effective method for evaluating muscular fitness in children (Chung et al., 2013). The SLJ has also been demonstrated to be a reliable and valid measure of lower-body explosive strength in school-aged children (Fernandez-Santos et al., 2015).

The average musculoskeletal fitness score among students at SMP Strada Santa Anna, as measured by the SLJ test, was 151.43 ± 36.92 cm (Table 2). Compared with a study conducted among adolescents aged 12–17 years in China, which reported an average SLJ score of 175.20 ± 29.31 cm (Zhu et al., 2017), the score observed in this study was relatively lower. This difference may be attributed to ethnic, environmental, and sociodemographic factors. Moreover, limited research using the SLJ to assess musculoskeletal fitness among Indonesian adolescents aged 12–14 years has resulted in a lack of normative reference data for this population.

Sex was found to be significantly associated with musculoskeletal fitness. Independent samples t-test results demonstrated a significant difference in SLJ scores between boys and girls ($p < 0.05$), with boys achieving higher scores. These differences can be explained by physiological and hormonal changes during puberty. Boys experience greater increases in steroid hormones, growth hormone, and bone mineral content, whereas girls tend to experience increased adipose tissue accumulation and relatively lower gains in muscle strength due to elevated estrogen secretion. Testosterone plays a critical role in enhancing bone and muscle growth while reducing fat accumulation in the lower extremities, which contributes to superior SLJ performance among boys (Chung et al., 2013; Marshall, 1978).

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Muscle strength and power training are widely recognized as central components of physical performance improvement (Sarfabadi et al., 2023). Independent t-test results showed a significant difference in musculoskeletal fitness between students who participated in strength training and those who did not (Table 3). Strength training, such as plyometric exercises, has a strong effect on SLJ performance (Kryeziu et al., 2023; Peitz et al., 2018).

Adolescent nutritional status is commonly assessed using body mass index-for-age (BMI/A). Correlation analysis in this study revealed a negative relationship between BMI/A and musculoskeletal fitness ($r = -0.167$), indicating that higher BMI/A tended to be associated with lower fitness levels. However, this result was not statistically significant ($p < 0.08$), and thus cannot be used to draw a definitive conclusion. This finding contrasts with studies by Artero et al., (2010); Primadiyanti et al., (2019), which reported a significant negative association between BMI/A and fitness. However, the relationship between BMI and fitness levels has shown inconsistent results across studies. In line with Rahmayanti & Sudiarti, (2019), students with higher BMI/A were still able to perform well in fitness tests. Wu et al. (2024) also found that both underweight and overweight individuals tend to have lower physical fitness compared to those with normal BMI.

Physical activity is defined as bodily movement produced by skeletal muscles that results in energy expenditure (Siscovick et al., 1985). Higher levels of physical activity in adolescents are associated with improved bone mass, neuromuscular function, muscular strength, and reduced risk of fractures in adulthood (Tveit et al., 2015). In this study, correlation analysis demonstrated a moderate and statistically significant positive association between physical activity and musculoskeletal fitness ($r = 0.433$). The coefficient of determination indicated that physical activity accounted for 18.7% of the variance in musculoskeletal fitness ($R^2 = 0.187$). Weight-bearing activities such as running, jumping, and active play impose mechanical loads on bones, stimulating remodeling and adaptive processes that enhance bone density and musculoskeletal strength (Faienza et al., 2023; Goodman et al., 2015; HHS, 2018).

Adequate energy and macronutrient intake are essential to support optimal body composition, maintain physical performance, and facilitate recovery during physical activity (Kerksick et al., 2017). The present study identified a weak but statistically significant positive association between energy intake and musculoskeletal fitness ($r = 0.214$), with energy intake explaining 4.6% of the variance ($R^2 = 0.046$). Sufficient energy intake is necessary to support muscle development, endurance, and overall athletic performance (Diva Rismanandi et al., 2022; Kerksick & Kulovitz, 2013). Conversely, prolonged inadequate energy intake may lead to fatigue and impair muscle strength, endurance, immune function, endocrine balance, and musculoskeletal development (Burke et al., 2006).

Carbohydrate intake plays a crucial role in physical performance, particularly during moderate-to-high intensity exercise, as carbohydrates serve as the primary energy substrate (Burke et al., 2011). This study demonstrated a weak but significant positive correlation between carbohydrate intake and musculoskeletal fitness ($r = 0.254$), accounting for 6.4% of the variance ($R^2 = 0.064$). During anaerobic activities such as the SLJ, carbohydrates are metabolized into glucose and subsequently converted into adenosine triphosphate (ATP), which fuels muscle contraction. Adequate carbohydrate intake helps maintain muscle and liver glycogen stores, thereby supporting optimal performance and delaying fatigue (Deng, 2023; Jentjens & Jeukendrup, 2003).

Protein intake is another important determinant of muscular strength and adaptation (Rasmussen et al., 2000). In this study, protein intake showed a weak but statistically significant positive correlation with musculoskeletal fitness ($r = 0.189$), explaining 3.6% of the variance ($R^2 = 0.036$). Protein supports muscle protein synthesis and the repair of muscle

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fibers damaged during anaerobic exercise, thereby enhancing recovery, adaptation, and performance (Deng, 2023). Adequate protein intake also promotes a positive protein balance, contributing to muscle hypertrophy and improved muscular strength (Rasmussen et al., 2000).

Fat serves as an important energy source during physical activity, particularly during low-intensity and long-duration exercise (Campbell, 2014). In this study, a positive but statistically insignificant correlation ($r = 0.103$, $p = 0.283$) was observed between fat intake and musculoskeletal fitness, indicating that the direction of the relationship cannot be used to draw conclusions. These findings differ from those of Primadiyanti et al. (2019) and Rahmayanti & Sudiarti (2019), who reported a significant positive association. The lack of variability in fat intake among participants—most of whom consumed less fat than the recommended levels—may explain the non-significant result. Moreover, fat is mainly used as an energy source during low-intensity, long-duration activities (Deng, 2023). Since SLJ is a high-intensity, short-duration activity, it does not rely heavily on fat as an energy source (Clifford & Maloney, 2015; Kerksick & Kulovitz, 2013).

Several limitations of this study should be acknowledged. The SLJ test was conducted at different times according to each class's physical education schedule, which may have introduced fatigue-related variability. Ideally, testing should be standardized and conducted at the same time of day, preferably in the morning. Nevertheless, efforts were made to minimize variability by implementing standardized warm-up routines led by physical education teachers, using consistent equipment and instructions, and encouraging participants to obtain sufficient sleep and consume breakfast prior to testing.

CONCLUSION

Musculoskeletal fitness represents a critical health biomarker in children and adolescents, yet evidence based on the Standing Long Jump (SLJ) test among Indonesian adolescents aged 12–14 years remains limited, with normative reference data still lacking. The findings of this study demonstrate that the musculoskeletal fitness level of students at SMP Strada Santa Anna in 2025 was predominantly within the average category. A statistically significant difference in SLJ performance was observed between male and female students, underscoring the influence of biological and physiological factors during adolescence. Furthermore, this study provides empirical evidence that physical activity, energy intake, carbohydrate intake, and protein intake are significant determinants of musculoskeletal fitness among junior high school students. In contrast, body mass index-for-age and fat intake were not significantly associated with SLJ performance.

AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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