Evaluating the impact of Physical Education on sedentary lifestyles in Indonesian students

Evaluación del impacto de la Educación Física en los estilos de vida sedentarios de los estudiantes Indonesios

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Abstract

Introduction: Sedentary behavior among Indonesian adolescents necessitates effective physical education to enhance health outcomes.
Objective: This study examined the correlation between physical education engagement and sedentary behavior in North Sumatra high school students, while evaluating physical fitness, PE characteristics, gender disparities, and devising evidence-based improvement strategies for PE.
Methodology: A cross-sectional quantitative analysis involving 327 students aged 15-18 from 12 North Sumatra high schools was performed, utilizing the International Physical Activity Questionnaire, fitness assessments, and classroom observations, alongside various statistical techniques.
Results: Approximately 46.8% of students displayed inadequate physical activity, averaging 8.5 hours of sedentary behavior daily, with only 26.9% adhering to WHO guidelines, revealing notable gender differences (females: 23.3% vs. males: 30.4%). During PE classes, students experienced 45% sedentary behavior and merely 4% vigorous activity, with regression analysis indicating that additional PE sessions reduced sedentary time by 42.6 minutes daily.
Discussion: Existing PE practices inadequately address health requirements, underscoring the pressing need for reform to enhance student participation in PE through innovative strategies.
Conclusions: The findings reveal a concerning prevalence of sedentary behavior and limited PE involvement among secondary school students in North Sumatra.

Keywords

Physical activity; sedentary behavior; physical education; adolescents; Indonesia.

Resumen

Introducción: Un estilo de vida sedentario entre los adolescentes indonesios requiere intervenciones de educación física eficaces para obtener mejores resultados de salud.
Objetivo: Este estudio investigó la relación entre la participación en la educación física y los estilos de vida sedentarios en estudiantes de secundaria del norte de Sumatra, evaluando las condiciones físicas, las características educativas y las diferencias de género y proponiendo estrategias de mejora basadas en la evidencia.
Metodología: Se realizó un estudio cuantitativo transversal con 327 estudiantes de 15 a 18 años de 12 escuelas secundarias de Sumatra Septentrional, utilizando el cuestionario internacional sobre actividad física, evaluaciones del estado físico, observaciones del aula y varios análisis estadísticos.
Resultados: Los resultados indicaron que el 46,8% de los estudiantes realizaba una actividad física insuficiente, con un promedio de 8,5 horas de comportamiento sedentario al día, y que solo el 26,9% cumplía las directrices de la WHO, lo que mostraba importantes disparidades de género (mujeres: 23,3% frente a hombres: 30,4%). Durante las clases de educación física, los estudiantes mostraron un 45% de comportamiento sedentario y solo un 4% de actividad vigorosa, y un análisis de regresión mostró que el aumento de las sesiones de educación física redujo el tiempo de sedentarismo en 42,6 minutos diarios.
Discusión: Las metodologías de educación física existentes no cumplen adecuadamente con los requisitos de salud, lo que hace hincapié en la necesidad urgente de introducir reformas para mejorar la participación de los estudiantes mediante estrategias innovadoras.
Conclusión: Los resultados ponen de manifiesto una preocupante prevalencia de estilos de vida sedentarios y una baja participación en la educación física entre los estudiantes de secundaria del norte de Sumatra.

Palabras clave

Actividad física; comportamiento sedentario; educación física; adolescentes; Indonesios.

Introduction

Sedentary lifestyles have emerged as a significant public health concern globally, with particular relevance for adolescent populations. The World Health Organization (WHO) estimates that 81% of adolescents aged 11-17 years worldwide do not meet the recommended 60 minutes of moderate-to-vigorous physical activity daily (Guthold et al., 2019; Insufficiently Active (Crude Estimate), 2023). This trend is equally concerning in Indonesia, where national health surveys indicate that 85.5% of adolescents are insufficiently active, with particularly high rates in urban and peri-urban regions (Andriyani et al., 2020).

Physical education programs in schools represent a potentially crucial intervention point, as they can reach virtually all adolescents regardless of socioeconomic status or other demographic factors (Ferrari et al., 2022; Silva et al., 2022). These programs offer a unique opportunity to promote healthy lifestyle habits and combat the growing prevalence of sedentary behaviors among young people. By providing structured physical activity and education, PE programs can play a pivotal role in shaping the physical, mental, and social well-being of students from diverse backgrounds (Kohl et al., 2013). Through regular participation in PE, adolescents can develop the knowledge, skills, and motivation to maintain active lifestyles that extend beyond the classroom, ultimately contributing to the prevention of sedentary lifestyles and associated health risks (Danielsen et al., 2023; D'Anna et al., 2024).

Physical education has been widely recognized as a critical component in promoting lifelong physical activity habits and reducing sedentary behavior among students (Friskawati et al., 2020). PE programs can play a pivotal role in shaping the physical, mental, and social well-being of students from diverse backgrounds by providing structured physical activity and health education (Nashwan, 2024). Through regular participation in PE, adolescents can develop the knowledge, skills, and motivation to maintain active lifestyles that extend beyond the classroom, ultimately contributing to the prevention of sedentary lifestyles and associated health risks (Bartzsch, 2024; Yin et al., 2024). However, the actual effectiveness of existing PE programs in achieving these goals requires further empirical investigation, particularly in developing countries like Indonesia where research in this domain remains limited.

Existing research on the effectiveness of physical education in reducing sedentary behaviour among students reveals several notable trends. Systematic reviews have consistently found that well-designed, school-based physical activity interventions can lead to meaningful increases in physical activity levels and improvements in various fitness markers among children and adolescents (Gkintoni et al., 2024). These studies underscore the potential of PE programmes to serve as a crucial mechanism in promoting active lifestyles and combating the pervasive issue of physical inactivity within young populations. The positive findings from these reviews emphasise the importance of implementing well-structured, evidence-based PE curricula that can effectively motivate and enable students to engage in regular physical activity, ultimately contributing to the prevention of sedentary behaviours (Gkintoni et al., 2024). However, the specific characteristics and design elements of PE programmes that yield the most significant reductions in sedentary time remain an area requiring further exploration, particularly in diverse socioeconomic and cultural contexts such as Indonesia (Fisher et al., 2011; Irfannuddin et al., 2021). Studies from Western contexts have demonstrated associations between quality PE programs and reduced screen time (D'Anna et al., 2024; Hanifah et al., 2023), improved cardiorespiratory fitness and better self-efficacy regarding physical activity (Malagodi et al., 2023; Nashwan, 2024). However, the generalizability of these findings to Southeast Asian contexts, including Indonesia, is questionable due to cultural, infrastructural, and curricular differences.

Research in similar developing contexts has shown mixed results. A study reported modest effects of PE interventions on reducing sedentary behaviour, while other research demonstrated more substantial impacts among urban adolescents but limited effectiveness in rural settings (Grauduszus et al., 2024). In Indonesia specifically, Dewi et al. examined PE programs in Indonesian schools, finding positive associations with physical activity levels but methodological limitations precluded definitive conclusions regarding sedentary behaviour reduction (Dewi et al., 2020; Hanifah et al., 2023).

Several critical gaps exist in the current understanding of PE effectiveness in Indonesia. Most existing studies focus on general physical activity levels rather than specifically measuring the reduction of sedentary behavior, which represents a distinct health behavior requiring targeted investigation. Furthermore, research predominantly examines urban populations, with limited inclusion of provincial areas

such as North Sumatra, where cultural and infrastructural factors may significantly influence program effectiveness. Methodologically, few studies utilize comprehensive assessment methods that combine subjective measures (e.g., questionnaires) with objective physical fitness testing and observational data. Limited research has explored potential gender differences in PE program effectiveness, despite evidence suggesting differential responses to physical activity interventions between adolescent males and females. Finally, the relationship between specific PE program characteristics (e.g., curriculum design, frequency, intensity) and sedentary behavior outcomes remains inadequately explored in Indonesian contexts.

This research addresses these gaps by providing a comprehensive assessment of PE effectiveness in North Sumatra Province high schools, utilizing multiple measurement approaches to triangulate findings. The study specifically examines sedentary behavior as a distinct outcome measure while also assessing relationships with physical fitness parameters. By focusing on provincial high schools, the research extends beyond urban-centric studies to include more diverse student populations. Additionally, the study evaluates potential gender differences in program effectiveness, which may inform more targeted interventions.

The findings have potential implications for PE policy and curriculum development in Indonesia, providing evidence-based guidance for optimizing PE programs to combat rising sedentary behavior among adolescents (Hanifah et al., 2023). As Indonesia continues to experience rapid socioeconomic development and technological advancement, understanding effective approaches to reducing sedentary behavior becomes increasingly important for public health planning.

This study aims to: examine the association between rates of physical education participation and patterns of sedentary behaviour among high school students in North Sumatra Province; assess the correlation between physical fitness measures and daily physical activity levels; determine the minimum effective frequency and intensity of PE required to significantly reduce sedentary behaviour; identify any gender differences in the effectiveness of PE programmes and their implications for curriculum design; and develop evidence-based recommendations to optimise PE programmes and prevent sedentary lifestyles among Indonesian adolescents.

Method

This research employed a quantitative cross-sectional design to assess relationships between PE participation, physical fitness, and sedentary behavior. Data collection occurred between September 2022 and January 2023, with fitness testing and questionnaire administration conducted during regular school hours. The research team consisted of trained physical education specialists, exercise physiologists, and research assistants who received standardized training in all assessment protocols prior to data collection.

Participants

The study population comprised high school students from North Sumatra Province, Indonesia. Using stratified random sampling, 327 students (168 males, 159 females) aged 15-18 years (mean age = 16.4 ± 1.2 years) were recruited from 12 high schools representing urban, suburban, and rural areas. The sample size was determined using G*Power analysis with $\alpha = 0.05$, power $(1-\beta) = 0.90$, and an expected effect size of 0.25 based on previous similar research.

Inclusion criteria required participants to be: (1) enrolled full-time in grades 10-12, (2) physically able to participate in regular PE classes without medical restrictions, and (3) willing to complete all assessment components with parental consent. Students with chronic medical conditions that significantly limited physical activity were excluded. The study protocol was approved by the Institutional Ethics Committee of the Universitas Negeri Semarang (approval number: UNNES/EC/2024-155), and written informed consent was obtained from all participants and their parents/guardians.

Procedure

The study was conducted in three phases: (1) preliminary school and participant recruitment, (2) data collection through questionnaires, fitness testing, and PE class observations, and (3) data analysis and

interpretation. Schools were categorized according to their PE program characteristics, including weekly frequency (1-2, 3, or ≥4 sessions), average session duration (30-45, 45-60, or >60 minutes), and curriculum approach (traditional sports-based, fitness-oriented, or activity-choice models).

Instrument

This table provides a comprehensive overview of the research instruments, their descriptions, measured variables, and key measurement approaches used in the study.

Table 1. Research Instruments, Procedures, and Key Measurements for Physical Activity and Fitness Assessment

	Test Procedure	Description	Variables	Key Measurements
1.	International Physical Activity Questionnaire (IPAQ) (Papathanasiou et al., 2010)	Validated long-form Indonesian version assessing daily physical activity and sedentary behavior	Daily Sedentary Time Physical Activity Level PE Session Frequency WHO physical activity recommendation compliance	- Total physical activity (MET-minutes/week) - Activity level categorization (low, moderate, high) - Average daily sedentary time (minutes/day)
2.	Physical Fitness Testing (Shomoro & Mondal, 2014)	Comprehensive fitness assessment battery under standardized conditions	Cardiorespiratory Fitness (VO_2max)	20-Meter Beep Test: Estimated VO_2max: Level and number of shuttles completed
			Lower Body Power	Vertical Jump Test: Highest jump height (cm)
			Muscular Endurance	30-Second Sit-Up Test: Total complete repetitions
			Flexibility	Sit and Reach Test: Furthest reach distance (cm)

Data analysis

Statistical analysis was conducted employing SPSS version 28.0. The investigation utilized a meticulous statistical framework to analyze the intricate interconnections among physical education, physical activity, and sedentary behavior in high school students residing in North Sumatra. Descriptive statistics were initially employed to summarize key data attributes, highlighting general trends in physical activity and sedentary behavior. Pearson correlation analysis was used to assess the strength and direction of relationships between sedentary time, activity levels, education session frequency, and fitness metrics. Correlation coefficients were computed to clarify connections among various dimensions of physical activity and fitness. The advanced aspect of the methodology involved multiple linear regression analysis, facilitating predictions of sedentary time based on multiple independent variables. This approach identified significant predictors of sedentary behavior through beta coefficients, standard errors, and assessments of statistical significance, along with R^2 and adjusted R^2 values to evaluate the model's explanatory capacity.

Statistical significance testing was essential, utilizing p-values to confirm result reliability, distinguishing between statistically significant ($p < 0.05$), highly significant ($p < 0.01$), and non-significant findings. This methodological rigor ensured that the identified relationships were meaningful rather than coincidental. Lastly, comparative analysis techniques were employed to investigate differences between groups, particularly between male and female students. Statistical tests were conducted to compare variables across demographic categories, revealing significant differences in physical activity, fitness levels, and sedentary behavior. This comprehensive statistical framework provided an in-depth understanding of physical education and activity patterns among high school students in North Sumatra, yielding important insights for future interventions and policy implications.

Results

Participant Demographics

The participant demographics table illustrates the balanced distribution of students across gender, age groups, geographic locations, and school grades in the study sample.

Table 2. Participant Demographics by Total Sample, Gender, and School Characteristics

Characteristic	Total (n=327)	Males (n=168)	Females (n=159)
Age (years)	16.4 ± 1.2	16.5 ± 1.3	16.3 ± 1.1
Urban	142 (43.4%)	73 (43.5%)	69 (43.4%)
Suburban	112 (34.3%)	58 (34.5%)	54 (34.0%)
Rural	73 (22.3%)	37 (22.0%)	36 (22.6%)
Grade 10	109 (33.3%)	56 (33.3%)	53 (33.3%)
Grade 11	109 (33.3%)	56 (33.3%)	53 (33.3%)
Grade 12	109 (33.3%)	56 (33.3%)	53 (33.3%)

This table shows the balanced distribution of the study sample across important demographic variables. The study included 327 high school students with a near-equal distribution between males (n=168, 51.4%) and females (n=159, 48.6%). The mean age was 16.4 years, typical for high school students. The sample represented a diverse geographic distribution, with the largest proportion from urban areas (43.4%), followed by suburban (34.3%) and rural areas (22.3%). The researchers ensured equal representation across grade levels (33.3% each for grades 10-12). This balanced distribution strengthens the study's external validity and allows for meaningful comparisons across gender, location, and grade levels without significant demographic confounding factors.

Activity Levels and Sedentary Behavior

This table presents a detailed breakdown of physical activity levels, sedentary behavior patterns, and gender-based differences among the studied high school students.

Table 3. Physical Activity Levels, Sedentary Behavior, and WHO Guideline Compliance by Gender

Parameter	Total (n=327)	Males (n=168)	Females (n=159)	p-value
Physical Activity Category				<0.01
- Low	153 (46.8%)	70 (41.7%)	83 (52.2%)	
- Moderate	89 (27.2%)	48 (28.6%)	41 (25.8%)	
- High	85 (26.0%)	50 (29.8%)	35 (22.0%)	
Meeting WHO Guidelines	88 (26.9%)	51 (30.4%)	37 (23.3%)	<0.05
Total Physical Activity (MET-min/week)	1824 ± 748	1946 ± 802	1696 ± 672	<0.01
Daily Sedentary Time (min/day)	510 ± 112	486 ± 104	535 ± 116	<0.001
Average Screen Time (hr/day)	4.8 ± 1.9	4.6 ± 2.0	5.0 ± 1.8	NS

This table reveals a concerning profile of physical activity and sedentary behavior among the students. Nearly half (46.8%) of all students exhibit low physical activity levels, with only 26.9% meeting the WHO's recommended physical activity guidelines. The data shows significant gender disparities, with females demonstrating higher rates of physical inactivity (52.2% vs. 41.7% for males) and lower rates of meeting WHO guidelines (23.3% vs. 30.4%).

Perhaps most alarming is the average daily sedentary time of 510 minutes (8.5 hours) per day, with females spending significantly more time sedentary than males (535 vs. 486 minutes, $p<0.001$). This represents more than half of students' waking hours spent in sedentary behaviors. Additionally, students spend nearly 5 hours daily on screens, with no significant gender difference in screen time specifically.

The total physical activity measured in MET-minutes per week (1824 ± 748) falls below recommended levels for adolescents, with males showing significantly higher activity levels than females ($p<0.01$). These findings highlight a critical public health concern, particularly for female students who exhibit more sedentary behavior patterns than their male counterparts.

Physical Education Program Characteristics

The table reveals the structural characteristics of physical education programs across the 12 schools studied, including session frequency, duration, and curriculum approaches.

Table 4. Characteristics of Physical Education Programs Across Schools

Parameter		Frequency (n=12 schools)	Percentage
PE Session Frequency	- 1-2 sessions/week	9	75.0%
	- 3 sessions/week	2	16.7%
	- ≥4 sessions/week	1	8.3%
Average Session Duration	- 30-45 minutes	7	58.3%
	- 45-60 minutes	4	33.3%
	- >60 minutes	1	8.3%
Curriculum Approach	- Traditional sports-based	5	41.7%
	- Fitness-oriented	4	33.3%
	- Activity-choice models	3	25.0%

This table exposes significant structural limitations in physical education programs across the 12 schools studied. The overwhelming majority of schools (75%) offer only 1-2 PE sessions per week, which falls below the optimal frequency for developing and maintaining physical fitness in adolescents. Similarly, most schools (58.3%) limit PE sessions to 30-45 minutes, which, when accounting for changing clothes, administrative tasks, and instructions, leaves minimal time for actual physical activity.

Only a single school (8.3%) provided either the recommended session frequency (≥4 sessions/week) or duration (>60 minutes). This indicates a systemic undervaluation of physical education within the educational structure of the region.

Regarding curriculum approaches, traditional sports-based models dominate (41.7%), followed by fitness-oriented approaches (33.3%), with only 25% of schools employing modern activity-choice models that might better engage diverse student interests. This distribution suggests a potential mismatch between PE program design and the varying needs and preferences of different student populations, particularly when considering gender differences in physical activity engagement noted in other tables.

Physical Education Participation Statistics

This table provides insights into students' participation in physical education, including session frequencies, activity breakdown, and gender-based variations in PE engagement.

Table 5. Physical Education Participation Statistics and Activity Breakdown by Gender

Parameter	Total (n=327)	Males (n=168)	Females (n=159)	p-value
PE Session Frequency (Students)				NS
- 1-2 sessions/week	242 (74.0%)	123 (73.2%)	119 (74.8%)	
- 3 sessions/week	55 (16.8%)	28 (16.7%)	27 (17.0%)	
- ≥4 sessions/week	30 (9.2%)	17 (10.1%)	13 (8.2%)	
PE Class Activity Breakdown				
- Sedentary time	45.0%	43.2%	46.9%	<0.05
- Light activity	32.0%	31.5%	32.5%	NS
- Moderate activity	19.0%	20.2%	17.7%	<0.05
- Vigorous activity	4.0%	5.1%	2.8%	<0.01
Average Active Time in PE Class	24.8 ± 4.6 min	26.3 ± 4.8 min	23.2 ± 4.3 min	<0.01

This table reveals critical deficiencies in both the quantity and quality of physical education participation. The student participation data mirrors the school program characteristics, with 74% of students receiving only 1-2 PE sessions weekly, and merely 9.2% receiving the more optimal frequency of ≥4 sessions per week. This distribution is similar across genders, with no significant differences in PE session frequency.

The most troubling finding is the PE class activity breakdown, which shows students spend nearly half (45%) of their PE class time in sedentary positions - primarily listening to instructions, waiting for turns, or transitioning between activities. Only 23% of class time involves moderate-to-vigorous physical activity (19% moderate + 4% vigorous), which falls significantly below health recommendations suggesting at least 50% of PE class time should involve substantial physical activity.

Gender disparities are evident in activity levels during PE, with females spending significantly more time sedentary (46.9% vs. 43.2%, $p<0.05$) and less time in moderate (17.7% vs. 20.2%, $p<0.05$) and vigorous

activities (2.8% vs. 5.1%, p<0.01) compared to males. Overall, females average 3.1 fewer minutes of active time during PE classes (23.2 vs. 26.3 minutes, p<0.01). These differences suggest potential gender biases in PE implementation, with activities possibly catering more effectively to male students' interests or abilities.

Physical Fitness Metrics

The physical fitness metrics table documents the students' performance across various fitness parameters, highlighting significant gender-based differences in physical capabilities.

Table 6. Comprehensive Physical Fitness Metrics Comparing Male and Female Students

Parameter		Total (n=327)	Males (n=168)	Females (n=159)	p-value
Cardiorespiratory Fitness	- VO_2max (ml/kg/min)	42.3 ± 6.4	44.6 ± 6.8	39.8 ± 5.2	<0.001
	- Meeting Fitness Standards (%)	38.5%	42.9%	33.9%	<0.05
Lower Body Power	- Vertical Jump Height (cm)	38.6 ± 8.2	42.3 ± 7.9	34.7 ± 6.4	<0.001
Muscular Endurance	- 30-Second Sit-Up (repetitions)	22.5 ± 5.6	24.7 ± 5.9	20.1 ± 4.2	<0.001
Flexibility	- Sit and Reach Test (cm)	28.3 ± 7.4	26.5 ± 7.2	30.2 ± 7.1	<0.001

Interpretations: Males significantly outperform females in:

- VO_2max scores (44.6 vs. 39.8 ml/kg/min, p<0.001)
- Vertical jump height (42.3 vs. 34.7 cm, p<0.001)
- Sit-up repetitions (24.7 vs. 20.1, p<0.001)
- Percentage meeting cardiorespiratory fitness standards (42.9% vs. 33.9%, p<0.05)
- Females surpass males only in flexibility, as shown in the Sit and Reach Test (30.2 vs. 26.5 cm, p<0.001), which aligns with common physiological trends.
- Overall fitness levels are suboptimal, with only 38.5% of students meeting VO_2max standards.
- Gender disparities are statistically significant across almost all domains, highlighting the need for gender-sensitive physical education strategies to close these gaps in fitness outcomes.

This table documents substantial gender-based differences in physical fitness parameters, reflecting both biological differences and potentially the cumulative effect of disparities in physical activity engagement. Overall fitness levels for the entire sample are concerning, with only 38.5% of students meeting established fitness standards for cardiorespiratory fitness.

Males demonstrate significantly higher cardiorespiratory fitness (VO_2max: 44.6 vs. 39.8 ml/kg/min, p<0.001), lower body power (vertical jump: 42.3 vs. 34.7 cm, p<0.001), and muscular endurance (sit-ups: 24.7 vs. 20.1 repetitions, p<0.001). These differences exceed what would be expected from physiological differences alone, suggesting that behavioral and environmental factors may be contributing to these disparities.

The only fitness measure where females outperform males is flexibility (sit and reach: 30.2 vs. 26.5 cm, p<0.001), which is consistent with typical physiological gender differences. However, this advantage in flexibility does not compensate for deficits in other fitness domains that are more strongly associated with overall health outcomes.

The significantly lower percentage of females meeting fitness standards (33.9% vs. 42.9%, p<0.05) highlights the need for targeted interventions that address the specific barriers and motivational factors influencing female students' physical fitness development.

Pearson Correlation Coefficients Between Key Variables

This correlation matrix illustrates the statistical relationships between key variables such as daily sedentary time, physical activity levels, PE session frequency, and various fitness metrics.

Table 7. Pearson Correlation Coefficients Examining Relationships Between Physical Activity, Sedentary Time, Fitness, and PE Participation Variables

Variables	Daily Sedentary Time	Physical Activity Level	PE Session Frequency	Cardiorespiratory Fitness (VO_2max)	Lower Body Power	Muscular Endurance	Flexibility
Daily Sedentary Time	1.00	-0.68**	-0.53**	-0.61**	-0.48**	-0.42**	-0.26*
Physical Activity Level	-0.68**	1.00	0.57**	0.64**	0.51**	0.47**	0.21*
PE Session Frequency	-0.53**	0.57**	1.00	0.49**	0.43**	0.39**	0.18*
Cardiorespiratory Fitness	-0.61**	0.64**	0.49**	1.00	0.65**	0.58**	0.25*

Lower Body Power	-0.48**	0.51**	0.43**	0.65**	1.00	0.61**	0.22*
Muscular Endurance	-0.42**	0.47**	0.39**	0.58**	0.61**	1.00	0.29*
Flexibility	-0.26*	0.21*	0.18*	0.25*	0.22*	0.29*	1.00

*p < 0.05, **p < 0.01

This correlation matrix reveals the interconnected relationships between physical activity patterns, fitness metrics, and PE participation, providing important insights into potential intervention targets.

The strong negative correlation between daily sedentary time and physical activity level (-0.68, p<0.01) confirms these behaviors operate as opposing patterns - as one increases, the other typically decreases. This suggests that interventions targeting either sedentary reduction or physical activity increase may produce beneficial effects on the other.

PE session frequency shows a moderate negative correlation with sedentary time (-0.53, p<0.01) and a moderate positive correlation with physical activity level (0.57, p<0.01), supporting the potential role of increased PE frequency in promoting healthier activity patterns. This provides empirical support for policy recommendations to increase PE offerings.

Cardiorespiratory fitness (VO_2max) demonstrates the strongest relationships with both sedentary time (-0.61, p<0.01) and physical activity level (0.64, p<0.01), highlighting it as a key physiological marker linked to habitual activity patterns. The strong correlation between cardiorespiratory fitness and other fitness parameters (0.58-0.65) suggests these components tend to develop together.

Interestingly, flexibility shows the weakest correlations with other variables (0.18-0.29), suggesting it may be influenced by different factors than strength and endurance measures. This aligns with research indicating flexibility responds to different training stimuli than cardiorespiratory and muscular fitness components.

All correlations are statistically significant, though with varying strengths, confirming the interrelated nature of physical activity, PE participation, and fitness parameters.

Multiple Linear Regression - Predictors of Daily Sedentary Time

The regression analysis table identifies and quantifies the independent predictors of daily sedentary time, providing insights into the factors most strongly associated with sedentary behavior.

Table 8. Multiple Linear Regression Analysis of Predictors for Daily Sedentary Time

Predictor Variable	β Coefficient	Standard Error	p-value
PE Session Frequency	-42.6	8.4	<0.001
Cardiorespiratory Fitness	-3.8	0.9	<0.001
Physical Activity Level	-0.04	0.01	<0.001
Gender (ref: male)	22.4	7.3	<0.01
Lower Body Power	-1.2	0.6	<0.05
Muscular Endurance	-0.8	0.4	<0.05
Age	3.2	4.8	NS
Flexibility	-0.3	0.4	NS
Model R^2	0.68		
Adjusted R^2	0.64		

Interpretations:

- NS = Not significant
- PE session frequency is the strongest predictor of sedentary time reduction. Each additional weekly session is associated with 42.6 minutes less sedentary time per day (p<0.001).
- Cardiorespiratory fitness significantly reduces sedentary time: each unit increase in VO_2max equals a 3.8-minute decrease (p<0.001).
- Physical activity level also contributes meaningfully, though on a smaller scale (p<0.001).
- Gender is an independent predictor: females spend 22.4 more minutes per day being sedentary than males (p<0.01), even after controlling for other variables.
- Lower body power and muscular endurance both show smaller but significant inverse relationships with sedentary time (p<0.05).
- Age and flexibility are not significant predictors of sedentary time.
- The model explains 68% of the variance in sedentary behavior (Adjusted R^2 = 0.64), indicating strong explanatory power.

This multiple linear regression analysis identifies the key factors predicting students' daily sedentary time, providing crucial insights for intervention design. The model explains 68% of the variance in sedentary behavior (R^2 = 0.68), indicating strong predictive power.

PE session frequency emerges as the strongest predictor, with each additional weekly PE session associated with a substantial reduction of 42.6 minutes in daily sedentary time ($p<0.001$). This finding provides compelling evidence for increasing PE frequency as an effective strategy for reducing sedentary behavior.

Cardiorespiratory fitness also shows a significant inverse relationship with sedentary time, with each unit increase in VO_2max associated with a 3.8-minute reduction in daily sedentary time ($p<0.001$). This suggests that interventions targeting cardiovascular fitness may have beneficial effects on reducing sedentary behavior.

Gender is a significant independent predictor, with females averaging 22.4 more minutes of daily sedentary time than males ($p<0.01$), even after controlling for other factors. This gender effect underscores the need for targeted approaches that specifically address barriers to physical activity faced by female students.

Lower body power and muscular endurance also demonstrate significant, though smaller, associations with reduced sedentary time ($p<0.05$), while age and flexibility were not significant predictors (NS).

The high adjusted R^2 (0.64) confirms that the identified variables collectively account for a substantial portion of the variation in sedentary behavior, providing a strong empirical foundation for multifaceted intervention strategies targeting these specific modifiable factors.

Discussion

This research presents a comprehensive examination of the relationship between physical education participation and sedentary behavior among high school students in North Sumatra, Indonesia. The findings reveal several critical insights with significant implications for educational policy and public health interventions.

Prevalence and Patterns of Sedentary Behavior

The high prevalence of sedentary behavior (averaging 8.5 hours daily) and low physical activity (46.8% of students) documented in our study aligns with global trends reported by Guthold et al. (2019), yet exceeds the global average of 81% for adolescent physical inactivity. This suggests that Indonesian adolescents may face unique barriers to physical activity that require contextualized interventions. A systematic review by Silva et al. (2022) identified several barriers to adolescent physical activity in developing countries, including limited infrastructure, cultural constraints, and educational systems that prioritize academic achievement over physical development—all factors potentially relevant to the Indonesian context.

The gender disparity observed—with females demonstrating significantly higher sedentary time (535 vs. 486 minutes, $p<0.001$) and lower rates of meeting WHO guidelines (23.3% vs. 30.4%)—reflects patterns documented in similar contexts globally. Feraco et al. (2024) found that gender-based differences in physical activity are most pronounced during adolescence, with societal expectations and cultural norms regarding femininity often discouraging vigorous physical activity among females. Similarly, Armstrong et al. (2018) documented gender disparities in adolescent physical activity across diverse socioeconomic contexts, highlighting the pervasiveness of this phenomenon. In Indonesia specifically, Hanifah et al. (2023) noted that traditional gender roles may restrict female participation in public physical activities, particularly in more conservative regions.

The average screen time of nearly 5 hours daily represents another concerning dimension of sedentary behavior. This finding aligns with research by Tung et al. (2023), who identified screen time as a major contributor to sedentary behavior and associated health risks among adolescents globally. The non-significant gender difference in screen time suggests that while overall activity patterns differ by gender, screen-based sedentary behavior may transcend gender lines, possibly reflecting the ubiquitous nature of digital technology in contemporary adolescent life regardless of gender.

PE Program Structure and Effectiveness

Our findings reveal a substantial gap between current PE practices and student health needs. The predominance of low-frequency PE programs (75% offering only 1-2 sessions weekly) falls significantly short of recommendations for optimal adolescent physical activity development. According to World Health Organization guidelines (2023), adolescents should accumulate at least 60 minutes of moderate-to-vigorous physical activity daily, a target that infrequent PE sessions cannot substantially support. This structural limitation is compounded by the finding that only 23% of PE class time involves moderate-to-vigorous physical activity—less than half the recommended 50% threshold established by SHAPE America (2015) and the International Society for Physical Activity and Health (Kohl et al., 2013).

The insufficient active time in PE classes documented in our study (24.8 ± 4.6 minutes on average) mirrors findings from other developing contexts. Wang (2017) observed similar patterns in Chinese schools, where administrative tasks, instruction time, and waiting periods significantly reduced active learning time in PE. More concerning is our finding that 45% of PE class time is spent in sedentary positions, higher than the 30-40% reported in studies from more developed educational systems (Rocliffe et al., 2024). This suggests particular inefficiencies in PE implementation within the Indonesian educational context that require targeted intervention.

The strong negative correlation between PE session frequency and daily sedentary time (-0.53, $p<0.01$) provides compelling evidence that increasing PE frequency could be an effective strategy for reducing sedentary behavior. The regression analysis further strengthens this conclusion, indicating that each additional weekly PE session is associated with a substantial reduction of 42.6 minutes in daily sedentary time. This dose-response relationship aligns with longitudinal research by Hughey et al. (2021), who demonstrated that daily PE was associated with significantly higher youth aerobic fitness levels compared to less frequent offerings, with measurable benefits appearing after just one semester of increased PE frequency.

The correlation between PE participation and physical activity levels (0.57, $p<0.01$) suggests that PE may serve as a catalyst for broader activity engagement. This supports the model proposed by D'Anna et al. (2024), wherein quality PE experiences build movement competency and self-efficacy that transfer to increased physical activity in other contexts. The significant relationship between PE frequency and cardiorespiratory fitness (0.49, $p<0.01$) further indicates that regular PE participation may enhance physiological capacity for activity, creating a positive feedback loop that enables and encourages more active lifestyles.

Gender Disparities in PE Engagement and Effectiveness

The significant gender differences observed in PE participation quality—with females spending more time sedentary (46.9% vs. 43.2%, $p<0.05$) and less time in moderate-to-vigorous activity (20.5% vs. 25.3%, $p<0.01$)—suggest systematic biases in PE implementation. These findings align with research by Böhlke et al. (2024), who documented how traditional PE environments often create gendered spaces that privilege stereotypically masculine activities and interaction styles. Similarly, Hay and Macdonald (2010) identified how assessment practices in PE can reinforce gendered notions of ability, disadvantaging female students. Azzarito and Solomon (2004) further demonstrated how intersections of gender with social class and cultural identity can create complex barriers to PE engagement for diverse female students, particularly relevant in the multicultural Indonesian context.

The gender gap extends beyond participation patterns to fitness outcomes, with females showing significantly lower cardiorespiratory fitness (39.8 vs. 44.6 ml/kg/min, $p<0.001$), lower body power (34.7 vs. 42.3 cm vertical jump, $p<0.001$), and muscular endurance (20.1 vs. 24.7 sit-ups, $p<0.001$). While some physiological differences are expected, the magnitude of these disparities suggests environmental influences beyond biology. Comparable studies by Metz et al. (2024) found that traditional PE environments can create "unsettling experiences" for female students, leading to disengagement and performance anxiety that impair skill development and fitness acquisition.

The regression analysis identifies gender as an independent predictor of sedentary time, with females averaging 22.4 more daily sedentary minutes even after controlling for other factors ($p<0.01$). This finding parallels research by Nienhuis and Lesser (2020), who identified how gender-specific sociocultural factors influence physical activity patterns independently of physiological capacity or opportunity. In

the Indonesian context specifically, Dewi et al. (2020) noted how cultural expectations regarding appropriate female behavior can constrain physical activity opportunities, particularly during adolescence when gender roles often become more rigidly enforced.

These gender disparities have significant implications for educational equity and public health. Evans et al. (2023) emphasize that gender-responsive educational interventions are essential for achieving equitable outcomes, particularly in contexts where traditional gender norms may constrain female participation. The UNESCO report on quality physical education (2024) specifically highlights gender-sensitive PE provision as a critical component of effective programs, recommending gender-balanced activities, female role models, and attention to eliminating implicit biases in instruction and assessment.

Relationship Between Physical Fitness and Sedentary Behavior

The strong inverse correlation between cardiorespiratory fitness and sedentary time (-0.61, $p<0.01$) highlights the physiological connection between these factors and suggests a potential bidirectional relationship. Poor cardiorespiratory fitness may contribute to increased sedentary behavior by making physical activity subjectively more difficult and less rewarding, while sedentary behavior further diminishes cardiorespiratory capacity—creating a concerning feedback loop. This interpretation is supported by the regression analysis, which identifies cardiorespiratory fitness as a significant independent predictor of reduced sedentary time (-3.8 minutes per unit increase in VO_2max, $p<0.001$).

This relationship aligns with theoretical models proposed by Jeftic et al. (2023), who describe how fitness capacity influences exercise tolerance, perceived exertion, and ultimately activity choices. Similarly, Brown (2023) demonstrated how improved cardiovascular fitness enhances self-regulation of physical activity through increased exercise self-efficacy and reduced perceived barriers to activity (Fikri et al., 2024). The physiological mechanisms underlying this relationship likely involve improved mitochondrial function, cardiac output, and metabolic efficiency, which Malagodi et al. (2023) identified as mediators between fitness level and activity capacity.

The interrelationships among various fitness parameters (correlations ranging from 0.58-0.65 between cardiorespiratory fitness and other components) suggest that comprehensive fitness development, rather than isolated focus on single components, may be most effective in combating sedentary behavior. This aligns with research by Barney et al. (2020) advocating for multidimensional fitness approaches in physical education that develop balanced physical competencies. Heinrich et al. (2023) further demonstrated that programs developing multiple fitness domains simultaneously produced greater improvements in both physical activity levels and sedentary behavior reduction than single-component interventions.

The finding that lower body power and muscular endurance were significant independent predictors of reduced sedentary time in the regression model ($p<0.05$) suggests that strength and power development may play an underappreciated role in sedentary behavior patterns. This supports emerging research by Nashwan (2024) indicating that muscular strength enhances movement efficiency and reduces perceived effort during daily activities, potentially making active choices more appealing than sedentary alternatives.

PE Curriculum Approaches and Activity Engagement

The predominance of traditional sports-based PE curriculum models (41.7%) over more inclusive approaches such as activity-choice models (25%) may contribute to the observed limitations in PE engagement. Research by Ison et al. (2021) suggests that student-centered curriculum models that offer choice and autonomy are more effective at engaging diverse student interests and abilities. A systematic review by Barnett et al. (2019) found that models emphasizing physical literacy development through diverse movement experiences produce better long-term activity outcomes than traditional sports-focused curricula. The limited adoption of such approaches in North Sumatra schools may be constraining PE's potential to reduce sedentary behavior across all student populations.

The relatively higher proportion of fitness-oriented curriculum models (33.3%) represents a potential strength in the studied schools. Rocliffe et al. (2024) found that fitness-oriented PE approaches were more effective than traditional sports models at developing health-related fitness components, particu-

larly among previously inactive students. However, the effectiveness of these models depends on implementation quality, which our findings suggest may be compromised by high proportions of sedentary time and limited session duration.

Curriculum approaches may be particularly important for addressing gender disparities. The traditional sports-based models predominant in our sample have been identified by Barber (2016) as particularly problematic for inclusive participation, often privileging students with prior sports experience (predominantly males) and emphasizing competitive outcomes over personal development. Activity-choice models, by contrast, have demonstrated promise in engaging female students by providing autonomy, diverse activity options, and reduced performance anxiety (Mercy et al., 2022).

Structural and Implementation Challenges

Our findings reveal significant structural barriers to effective PE implementation, including insufficient time allocation (58.3% of schools offering only 30-45 minute sessions) and high proportions of sedentary time within classes (45% on average). These constraints likely stem from educational policies that undervalue PE relative to academic subjects, a phenomenon documented in various educational contexts by Palmer and Behrens (2017). The UNESCO global report on physical education (2024) identifies insufficient time allocation as a persistent challenge worldwide, with particularly pronounced time constraints in developing regions prioritizing academic achievement as measured by standardized assessments.

The substantial sedentary time within PE classes suggests implementation challenges beyond policy limitations. Andersen et al. (2014) identified how physical environment constraints, including limited facilities and equipment, can increase waiting time and reduce activity density in PE classes. In the Indonesian context specifically, Irfannuddin et al. (2021) noted how limited teacher training in efficient class management and activity organization contributes to excessive sedentary time during PE sessions. Wongsingha et al. (2023) further documented how COVID-19 disruptions have exacerbated implementation challenges in Southeast Asian physical education programs, potentially influencing the patterns observed in our study conducted in 2022-2023.

The finding that only 9.2% of students receive the more optimal frequency of ≥4 PE sessions weekly suggests that even when progressive policies exist, implementation may be inconsistent. This aligns with observations by Friskawati et al. (2020) regarding the gap between Indonesian PE curriculum standards and classroom practices, attributed to resource limitations, competing educational priorities, and insufficient professional development opportunities for teachers. Hermino and Arifin (2020) further noted how decentralized educational governance in Indonesia can create inconsistent implementation of national standards, resulting in significant variations in program quality across regions and schools.

Limitations and Future Research Directions

Several limitations warrant consideration when interpreting these findings. The cross-sectional design precludes causal inferences regarding the relationship between PE participation and sedentary behavior. While multiple regression analyses help identify predictive relationships, longitudinal studies are needed to establish causality and examine long-term effects. Furtado et al. (2023) demonstrated the value of longitudinal designs in distinguishing between temporary associations and true causal pathways in adolescent physical activity research.

Self-reported physical activity data via IPAQ may be subject to recall bias and social desirability effects, though the inclusion of objective fitness assessments helps mitigate this limitation. Future studies could strengthen measurement validity through accelerometry or other direct physical activity monitoring methods, as recommended by Fisher et al. (2011) for more accurate assessment of activity patterns.

The sample, while representative of North Sumatra Province, may not capture the full diversity of Indonesian contexts, particularly across different islands and cultural groups with distinct socioeconomic conditions and educational systems. Future research should expand to include more diverse geographic and cultural settings within Indonesia, as Andriyani et al. (2020) noted significant regional variations in adolescent physical activity patterns across the archipelago. Moreover, qualitative research could provide deeper insights into the barriers and facilitators of PE engagement, particularly regarding gender differences in participation and experience. Mixed-methods approaches as employed by Wilson (2011)

could be particularly valuable in exploring the complex sociocultural factors influencing PE effectiveness in diverse Indonesian contexts.

Future studies should also examine the implementation and effectiveness of various PE curriculum models in Indonesian contexts, with particular attention to approaches that may better engage female students and reduce gender disparities in participation. Saarinen et al. (2018) demonstrated the potential of personalized education approaches to address diverse learning needs, a concept that could be adapted to physical education to better accommodate varying interests, abilities, and cultural backgrounds. Research on policy interventions to increase PE frequency and quality would be valuable in translating these findings into practical recommendations for educational reform, particularly within the constraints of the Indonesian educational system as outlined (Mercy et al. 2022; Pardilla, 2021).

Conclusions

This study reveals a concerning prevalence of sedentary behavior and insufficient PE involvement among North Sumatra high school students. Approximately 47% of students exhibit low physical activity levels, with daily sedentary time averaging 8.5 hours—representing more than half of their waking hours. These patterns are particularly pronounced among female students, who demonstrate higher sedentary time and lower physical activity levels than their male counterparts.

The research identifies a clear relationship between PE participation and sedentary behavior, with each additional weekly PE session associated with a substantial 42.6-minute reduction in daily sedentary time. However, current PE programs appear inadequately structured to address this challenge, with 75% of schools offering only 1-2 sessions weekly, and 45% of PE class time spent sedentary. The gender disparities observed in PE engagement and effectiveness suggest that current programs may be failing to meet the needs of female students in particular.

These findings underscore the urgent need for comprehensive reforms to PE programs in Indonesian schools. Educational policymakers should prioritize increasing PE frequency to at least 3-4 sessions weekly and extending session durations to allow for meaningful activity engagement. PE curricula should be diversified to include more student-centered approaches that offer choice and autonomy, potentially better engaging diverse student interests and abilities. Gender-sensitive pedagogical approaches are needed to address the significant disparities observed between male and female students in both PE participation and fitness outcomes.

Physical education represents a crucial public health intervention point for Indonesian adolescents, with the potential to reach virtually all students regardless of socioeconomic status. By restructuring PE programs to provide more frequent, active, and inclusive opportunities for physical activity, schools can play a pivotal role in reducing sedentary behavior and promoting lifelong healthy habits. The strong associations observed between PE participation, physical fitness, and reduced sedentary time suggest that such interventions could yield substantial public health benefits.

Future implementation efforts should focus on addressing both structural barriers (such as time allocation and resource constraints) and pedagogical limitations (including high proportions of sedentary time within classes and gender biases in activity selection). By applying evidence-based approaches to PE reform, Indonesian schools can transform physical education from a marginalized subject into a cornerstone of comprehensive adolescent health promotion.

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