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Modeling the effects of physical activity and lifestyle on academic achievement: The mediating roles of physical fitness and self-confidence

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Abstract: This study developed and tested a theoretical model to explain the complex relationships between physical activity, lifestyle, fitness, self-confidence, and academic success. Employing a cross-sectional methodology, data were collected from 260 tenth-grade public high school students in Surabaya, Indonesia, selected through cluster random sampling. The measures included the International Physical Activity Questionnaire (IPAQ) for physical activity, the Healthy People Lifestyle Profile II (HPLP II) for lifestyle assessment, the Lauster scale for self-confidence evaluation, the beep test and bioelectrical impedance analysis for physical fitness assessment, and report card grades for academic performance. Data analysis was conducted using structural equation modeling. The principal findings reveal that physical exercise significantly impacted students' physical fitness, with intensity being a key factor. Additionally, lifestyle played an essential role, particularly in stress management and health accountability. Physical fitness was found to strongly influence self-confidence, which in turn had a substantial direct impact on academic performance. Importantly, physical fitness was shown to affect academic performance indirectly through the mediation of self-confidence, especially in physical education and science subjects. The formulated theoretical model demonstrated a significant alignment with the empirical data. These observations highlight the importance of educational strategies that integrate both physical and psychosocial aspects to effectively enhance academic performance and promote well-rounded, self-assured student identities.

Keywords: *Academic achievement, SEM-PLS, Lifestyle, Physical activity, Physical fitness, Self-confidence.*

1. Introduction

Providing Quality of life is greatly influenced by physical fitness, especially during adolescence, a critical developmental phase marked by accelerated cognitive and physical development. Sport aims to improve people's health and fitness through physical activity, exercise, and involvement in sports that facilitate learning and work performance. The understanding of the importance of sport is in contrast to the fact that initiatives undertaken by government agencies and local communities to build fitness facilities and programs have proven inadequate in fostering an active lifestyle among adolescents. For example, Physical Education is generally scheduled only once a week and often lacks adequate additional physical activity, despite the fact that regular participation in physical activity is essential for maintaining optimal fitness levels [1].

A recent meta-analysis and study in 2024 showed that physical activity plays a crucial role in improving adolescent mental health and supporting academic achievement, with moderate- to vigorous-intensity physical activity making the most significant contribution [2, 3]. The components of physical fitness that pertain to health encompass muscular strength, endurance, flexibility, cardiovascular endurance, and body composition. In this context, VO2max, body fat percentage, and fat-free mass emerge as essential metrics that significantly impact the physical performance of students [4, 5]. The most recent findings from the Sport Development Index (SDI) 2023 reveal a concerning situation

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regarding the physical fitness of Indonesian youth. A mere 5.04% of individuals aged 16–30 are deemed fit, whereas the overwhelming majority are categorised as having low or very poor fitness levels [6]. The situation is further intensified by the growing dependence of adolescents on electronic devices and their diminishing levels of physical activity, both of which adversely impact mental well-being and hinder academic achievement [7, 8]. Research findings from junior high school students in Pekanbaru and Sukoharjo indicate that a considerable number of students exhibit notably low VO2max levels [9]. A plethora of research indicates that adolescents exhibiting superior physical fitness levels tend to show enhanced concentration and academic performance, presumably as a result of the cognitive benefits linked to augmented cerebral blood flow during physical activity [10].

Recent research shows that physical activity has a significant positive impact, both directly and indirectly, on adolescents' academic engagement and performance. Furthermore, this activity also contributes to improved mental health by reducing negative emotions and strengthening psychological resilience [11]. Self-confidence is intricately linked to favourable views of one's capabilities, the bravery to confront obstacles, and the readiness to continue pursuing knowledge [12]. High self-confidence adolescents are more likely to participate fully in class, perform better, and exhibit higher resilience to academic challenges [13]. Consequently, the interplay between physical fitness and self-assurance is thought to exert a concurrent and substantial influence on the academic achievements of students.

The above discussion has motivated the authors to develop a theoretical model that explains the relationship between physical activity, lifestyle, physical fitness, self-confidence, and academic achievement by integrating concepts from exercise science, physical assessment, and psychology. This model incorporates self-confidence as a mediating variable to enhance theoretical understanding and provide practical insights for the formulation of more successful health education and policy initiatives. This transdisciplinary perspective is particularly relevant to explain the complex causal mechanisms linking physical and psychological elements in educational contexts. This research is unique through its interdisciplinary integration and the development of a structural model that has rarely been explored in the context of secondary education in Indonesia. While this research offers a unique interdisciplinary model for the Indonesian context, reviewing recent global or regional studies exploring similar structural relationships could provide deeper understanding. For example, several recent studies have formulated mediation models that integrate the roles of learning motivation, teacher support, and self-efficacy in explaining the relationship between physical activity and student engagement and academic performance [14].

2. Method

Approaches and methods are usually used in every research. Problem formulation, research objectives, and research hypotheses are usually associated with the approaches and methods used. To confirm the influence of maturity, this study used a cross-sectional study method, which is an observational study that analyzed data from a population at one point in time. This method also includes differences between age groups [15]. Previous theoretical and research methods based on the structural equation model were used to build this research model. The Smart PLS-3 software tool was also used.

2.1. Participant

The population of this study included all public high school students in Surabaya, Indonesia. Population refers to the entire group of people who share specific characteristics relevant to the purpose of the study, thus allowing for extrapolation of the results to this wider group. This study used cluster random sampling, a probability sampling method in which the population is divided into clusters specifically, classes within a school and random selection of these clusters is done to ensure representativeness and equal probability of selection for each member of the population [16]. This approach ensures excellent external validity while minimizing the time and cost associated with data collection. The final sample consisted of 260 tenth grade students from eight classrooms in two public high schools in Surabaya. The study used Structural Equation Modeling (SEM), a minimum sample size

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of 100-200 respondents is considered sufficient to conduct robust and reliable statistical analysis that can ultimately derive reliable conclusions from the research findings.

2.2. Instruments and Procedures

Data were collected using questionnaires, physical examinations, and documentation to comprehensively assess the factors under examination. Physical activity was evaluated using the short form of the International Physical Activity Questionnaire (IPAQ) developed by Booth, et al. [17] which quantifies the frequency, duration, and intensity of physical activity (Pa1, Pa2, Pa3). The Health-Promoting Lifestyle Profile II [18] was utilized to assess lifestyle behavior whose assessment has been modified without physical activity indicators, incorporating dimensions such as health responsibility, nutrition, spiritual growth, interpersonal connections, and stress management (Lb1, Lb2, Lb3, Lb4, Lb5). Using items total correlations analysis technique, the validity coefficient ranged from 0,28 to 0,75. Meanwhile, using cronbach's alpha, a reliability coefficient of 0,94 was obtained with total number of items is 43. Self-confidence was evaluated using a five-point scale questionnaire created by Lauster [12] which includes indicators of self-ability, optimism, objectivity, responsibility, and rational-realistic thinking (Sc1, Sc2, Sc3, Sc4, Sc5). Using items total correlations analysis technique, the validity coefficient ranged from 0,32 to 0,78. Meanwhile, using cronbach's alpha, a reliability coefficient of 0,79 was obtained with total number of items is 25. Body composition was assessed via bioelectrical impedance analysis (BIA) in accordance with Kim, et al. [19] to evaluate body fat mass, while physical fitness was quantified using the bleep test Leger and Lambert [20] to estimate VO2max (Pf1) and body composition (Pf2) as principal indicators. Academic achievement for one semester was assessed using school records (report cards). This included grades in the scientific (Aa1), and physical education (Aa2) disciplines. This strategy ensured the systematic collection of all relevant variables and their associated indicators for subsequent analysis.

2.3. Data Analysis

SEM comprises two interconnected phases. Initially, assess the model's validity by determining if a major disparity exists between the model and the data. Secondly, if there is a congruence between the model and the data (with an insignificant difference), the analysis can evaluate the structural relationship of the model to assess the theoretical model's adequacy through a goodness of fit test. If the null hypothesis is accepted, indicating no disparity between the model and the data, then the proposed theoretical model is appropriate for elucidating the data. Once an appropriate model has been established, each hypothesis may be evaluated, demonstrating the influence of one variable on another. The testing criteria are founded on the assessment of the measurement model (construct validity and reliability) and the structural model (R^2, Q^2, direct/indirect effects), along with the Standardized Root Mean Square Residual (SRMR), where a value of ≤ 0.08 is deemed satisfactory, while a value up to 0.10 is regarded as the tolerance threshold for a model exhibiting adequate fit, indicating an acceptable model fit [21]. The Normed Fit Index (NFI) should be at least 0.90, or preferably 0.95 according to recent standards. However, if the NFI falls below the recommended threshold for model fit, it may still be retained for theoretical justification, particularly in social and educational research [22].

This study employed a cross-sectional observational approach to examine the correlations between academic accomplishment, self-confidence, physical fitness, lifestyle, and physical activity in high school students at a specific instant. The cross-sectional method is suitable for identifying connections and potential structural routes among the observed parameters, as it allows for the simultaneous evaluation of multiple variables without affecting the study environment [23]. Data were collected from a representative sample of students, and the research model was developed using Structural Equation Modeling (SEM) in accordance with established theoretical frameworks and prior investigations using the SmartPls3 software. The SEM technique enabled a comprehensive analysis of both direct and indirect correlations among variables, providing a robust framework for understanding the complex interactions between student outcomes and determinants of physical fitness [24]. All measurements and

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analyses were conducted in accordance with the ethical standards and guidelines for observational studies. This study utilizes a research methodology that combines theoretical notions with empirical methods to systematically examine the relationship between crucial factors (Figure 1).

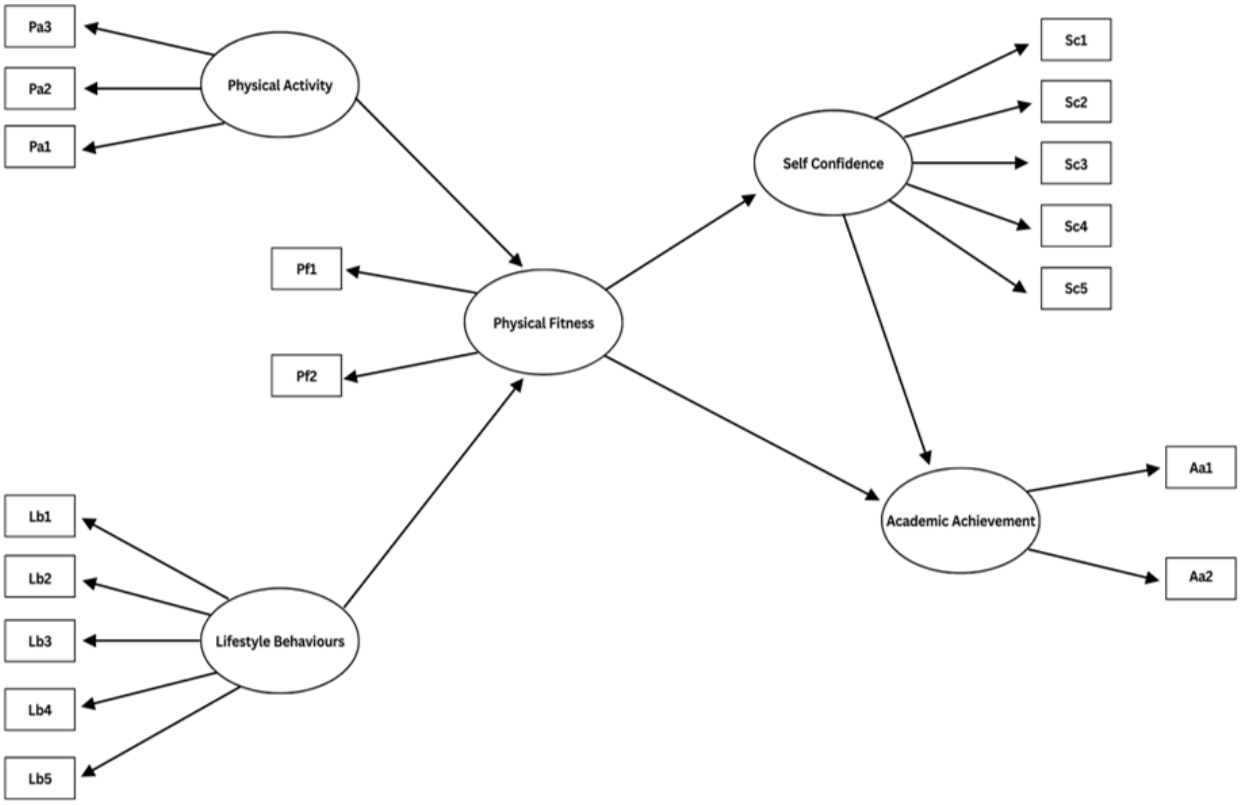

Figure 1.
Research Model.

3. Results

In SEM, two distinct types of models are established: measurement models, often referred to as outer models, and structural models, commonly known as inner models. This study includes 18 manifest variables and 5 latent variables. The physical activity variable is assessed through 3 manifest variables: frequency, duration, and intensity. The lifestyle variable comprises 5 manifest variables: health responsibility, nutrition, spirituality, interpersonal relationships, and stress management. The physical fitness variable consists of 2 manifest variables: VO2max and body composition. The self-confidence variable is represented by 5 manifest variables: self-confidence, optimism, objectivity, responsibility, and rationality. Lastly, the academic achievement variable includes 2 manifest variables: exact sciences and physical education, sports, and health.

The evaluation of the outer model serves to examine the relationship between latent variables and their corresponding indicators or manifest variables, commonly referred to as measurement models. To assess the outer model, validity and reliability tests are employed. The validity test on PLS is categorized into two types: Convergent Validity and Discriminant Validity. The validity in convergence is assessed using the outer loading value, where an indicator test result of ≥ 0.7 is considered valid. Conversely, if the outer loading value is ≤ 0.7, the indicator is deemed invalid. The analysis conducted with SmartPLS 3.0 software yielded the following findings:

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Table 1.
Convergent Validity Test of Theoretical Model.

Construct	Indicator	Loading Factor
Physical Activity	Pa1	0.733
	Pa2	0.756
	Pa3	0.869
Lifestyle Behavior	Lb1	0.838
	Lb2	0.763
	Lb3	0.613
	Lb4	0.803
	Lb5	0.847
Physical Fitness	Pf1	0.895
	Pf2	0.873
Self-Confidence	Sf1	0.740
	Sf2	0.647
	Sf3	0.922
	Sf4	0.802
	Sf5	0.768
Academic Achievement	Aa1	0.644
	Aa2	0.954

Source: Data processing 2025 Smartpls3.

Based on the loading factor values in the table above, all indicators have met the convergent validity standards (outer loading ≥ 0.7). Thus, all constructs have passed the convergent validity criterion so that the sieve is employed for further analysis. The analysis results indicate that the convergent validity test, utilizing Average Variance Extracted (AVE), yielded the following values: Physical Activity at 0.620, Lifestyle at 0.603, Physical Fitness at 0.781, Self-Confidence at 0.593, and Academic Achievement at 0.747. These findings demonstrate that all constructs within this research model possess an AVE value exceeding 0.5. The reliability assessment utilizing Composite Reliability and Cronbach's Alpha is presented as follows:

Table 2.
Composite Reability dan Cronbach Alpha.

Laten Variable	Cronbach's Alpha	Composite Reliability
Physical Activity	0.708	0.831
Lifestyle Behavior	0.892	0.876
Physical Fitness	0.720	0.877
Self-Confidence	0.868	0.876
Academic Achievement	0.678	0.854

Source: Data processing 2025 Smartpls3.

Based on the result of the reliability test, all constructs in the model exhibit a Composite Reliability value over 0.8 and a Cronbach's Alpha greater than 0.7. The academic success variable exhibits a Cronbach's Alpha value of 0.678, marginally below 0.7, while its Composite Reliability value is notably high at 0.854. Composite Reliability (CR) was selected as the primary metric of reliability due to its capacity to assess the internal consistency of the construct by accounting for the weights of various indicators, thereby yielding a more precise reliability estimate than Cronbach's Alpha (CA), which presumes uniform indicator weights [25]. This study demonstrates that the CR values for all constructions exceed the minimum threshold (> 0.7), indicating their reliability, despite certain CA values being marginally below 0.7.

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Table 3.
Inner Model Test.

Laten Variable	R Square
Physical Fitness	0.013
Self-Confidence	0.000
Academic Achievement	0.076

Source: Data processing 2025 Smartpls3.

This study employs a structural model utilizing the coefficient of determination (R^2) value. The thresholds for categorizing the R2 value are classified as follows: 0.67 indicates strong, 0.33 denotes moderate, and 0.19 signifies weak [25]. The R Square values are Physical Fitness of 0.013, Self-Confidence of 0.000, and Academic Achievement of 0.076. Although these values are somewhat low, the results offer initial insight into the relationships between the constructs in the model, with the remainder attributed to the influence of unmeasured factors in this study.

Table 4.
Goodness of Fit.

	R Square
SRMR	0.086
NFI	0.656

Source: Data processing 2025 Smartpls3.

In the model fit test, the SRMR score of 0.086 signifies that the constructed model exhibits a satisfactory level of fit, warranting acceptance. The NFI value of 0.656, while statistically below the suggested minimum for model fit, is retained for theoretical purposes, particularly in social and educational research [22].

Following a structural model analysis utilizing the partial least squares (PLS-SEM) method through SmartPLS, the bootstrapping procedure was employed to assess the significance of the relationship paths among the variables. In this model, a stronger influence of the latent variable path coefficient is indicated by a value that is greater, approaching either 1 or -1 [25].

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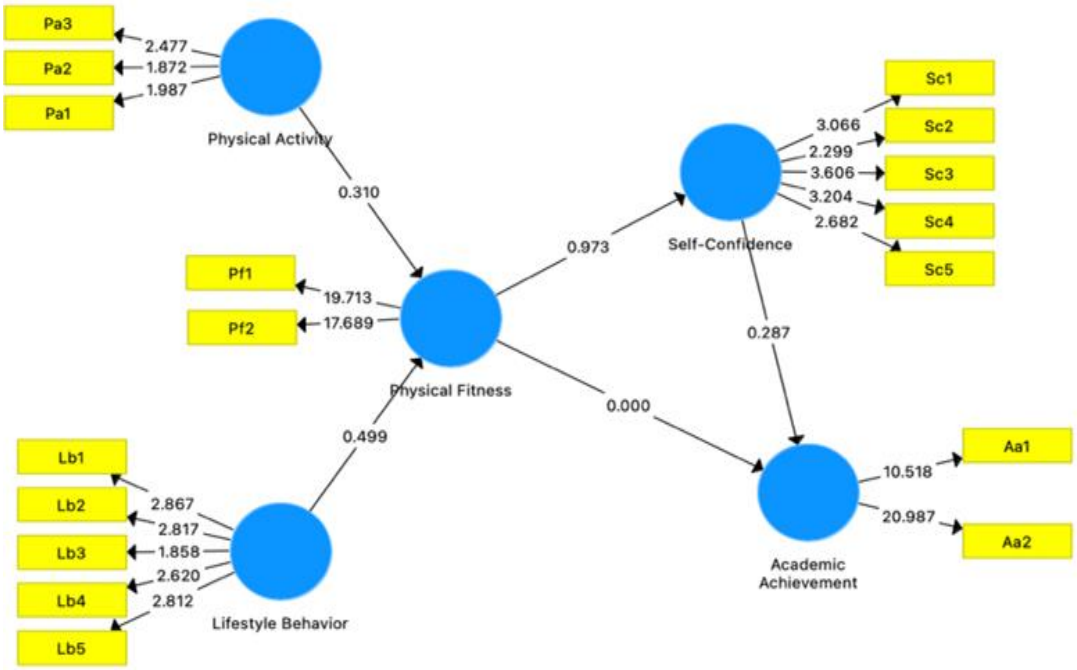

Figure 2.
Bootstrapping.

The path analysis's findings indicate a positive correlation between physical activity and fitness, with a path coefficient of 0.347. While the path coefficient of 0.496 indicates that lifestyle has a better impact on physical fitness. In addition, it has been established that physical fitness has a substantial direct effect on students' self-confidence with a path coefficient of 0.975. While the path coefficient of 0.000 implies that physical fitness does not directly help to increasing pupils' academic ability. Furthermore, self-confidence has a favorable and significant direct effect on academic achievement, with a path coefficient of 0.288. Based on these findings, to see the indirect effect of X on Z through Y, it is essential to multiply the path coefficients on each path traveled [26]. So, it can be inferred that physical fitness does not affect academic performance directly, but through self-confidence, with an indirect effect value of 0.280 which is the result of multiplying the path coefficient of physical fitness on self-confidence and self-confidence on achievement.

4. Discussion

Physical fitness is a crucial measure of pupils' entire development, encompassing physical, psychological, and cognitive dimensions. Research indicates that enhancing VO2max is strongly correlated with physical fitness, diminishes the likelihood of cardiovascular illness, augments metabolic capacity, and facilitates the body's physiological adaptation to rigorous physical exertion [27]. Conversely, body fat is significant, and elevated levels of fat are inversely associated to physical fitness. Recent research indicate that each 1% rise in body fat diminishes fitness scores and the body's functional capacity [28]. Consequently, preserving body fat composition and enhancing VO2max are crucial for augmenting total physical fitness.

The structural model analysis results indicated that physical activity significantly influenced physical fitness. These findings substantiate the notion that elevated cardiorespiratory fitness levels are intimately associated with long-term health outcomes. This study revealed that children and adolescents exhibited several physical health indicators with increased physical activity [29]. A meta-analysis of physical activity interventions in obese children and adolescents indicated that physical

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activity programs, particularly those of moderate to high intensity, enhanced VO2max and blood pressure [30]. It is important to recognise that the enhancement of physical fitness is determined by the quality of physical activity rather than its quantity, necessitating moderate to strenuous activity for a minimum period of 60 minutes daily [31-33].

A healthy lifestyle, which includes eating a balanced diet, getting adequate sleep, and practicing good stress management, is also linked to improved physical fitness, suggesting that lifestyle has a stronger impact on students' health. A study on Brazilian adolescents indicated that moderate to high-intensity physical exercise was substantially correlated with cardiorespiratory fitness, muscular strength, and body composition, resulting in increased muscle mass and reduced fat [34]. Unmeasured external factors, including genetic influences, dietary status, and the physical surroundings of students, may also impact their physical fitness levels [35, 36].

In this example, the findings indicate that physical fitness has no direct effect on academic achievement. This indicates that enhanced physical condition among kids does not directly correlate with improved academic performance. Rather, enhancement of psychological conditions is necessary as a connection [37]. This study demonstrates that self-confidence, as a mediating factor, significantly influences academic achievement. In summary, academic success is not solely determined by physical fitness; rather, enhanced self-confidence fosters more motivation, courage in confronting academic problems, and increased engagement in the learning process.

The biopsychosocial approach describes how academic achievement is determined by a complex interaction of biological (physical condition), psychological (self-confidence), and behavioural (physical activity and lifestyle) elements. This structural relationship model endorses this methodology. The findings of this study suggest that treatments aimed at enhancing students' academic performance should not solely concentrate on academic or cognitive dimensions; it is imperative to also address their physical and psychological well-being. Consequently, educational initiatives that promote increased physical activity, foster a healthy lifestyle, and enhance self-confidence are vital for supporting kids' comprehensive development, both academically and non-academically. This debate concludes that the findings substantiate the idea of a considerable structural association among physical activity, lifestyle, physical fitness, self-confidence, and students' academic achievement.

Students in good physical shape are more likely to have high levels of efficacy, self-confidence, and a positive self-image, which can be explained by the positive relationship between physical fitness and self-confidence. Moreover, confident pupils engage more actively in the learning process, express their viewpoints, withstand pressure, and have a strong motivation to learn. Consequently, self-confidence functions as a crucial intermediary in the indirect correlation between academic success and physical fitness. Similarly, physical fitness operates as a connection between self-confidence and physical activity and lifestyle, which eventually influences academic performance.

A fascinating discovery was that academic achievement is significantly influenced by self-confidence. Students with elevated self-confidence typically attain superior academic performance. This indicates that self-confidence serves as a psychological mechanism that motivates pupils to engage more actively in learning, confront challenges, and persist in the face of problems. The analysis indicates that among the five indicators of self-confidence influenced by physical fitness, the most significant is the objective aspect, followed by the responsible aspect, then the rational and realistic aspect, self-confidence, and lastly, the optimistic aspect. The objective indication holds the key position as individuals possessing superior physical condition are more likely to accurately evaluate their capabilities and limitations. Individuals who engage in effective exercise typically possess accurate self-evaluations and the capacity to make sound decisions [38]. Consequently, the objective indicator holds the paramount place. Physical health influences sentiments of responsibility, since those who are fit exhibit greater consistency and commitment to their responsibilities, enabling them to think logically, adaptively, rationally, realistically, and optimistically. Physical fitness enhances self-confidence by fostering a greater feeling of responsibility, logic, and objectivity. Consequently, physical fitness can serve as a foundation for creating programs aimed at enhancing self-confidence.

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The preceding explanation indicates that physical health enhances students' self-confidence, which then influences their academic performance indirectly. The results demonstrate that a comprehensive educational strategy, which considers both cognitive and students' physical and psychological dimensions, is crucial for enhancing learning quality and academic performance.

However, this study has several limitations. The cross-sectional nature of the design limits the ability to determine causality between the variables. The reliance on self-reported data, particularly for physical activity and lifestyle, may have introduced response biases. Additionally, the sample was limited to public high school students in Surabaya, which may limit the generalizability of the findings. Future research should consider longitudinal or experimental designs with broader and more diverse samples to validate and extend these findings. All things considered, this study provides theoretical and practical insights and emphasises the significant influence of psychological and physical elements on students' academic progress. The findings contribute to a deeper understanding of how physical and psychological factors jointly influence academic achievement in adolescents. These insights provide a basis for developing integrated educational and health interventions that enhance students' well-being and academic success.

5. Conclusions

This study reveals that students' physical fitness is highly influenced by physical activity, with intensity being the most crucial factor, followed by frequency and duration. Lifestyle elements, particularly stress management and health responsibility, also play a crucial role in moulding fitness. Physical fitness, in turn, promotes self-confidence, which mediates its impact on academic achievement. The strongest academic outcomes were connected with achievement in science and physical education. The structural model examined in this research was supported by the empirical data, with an adequate model fit (SRMR = 0.086), suggesting the robustness of the postulated correlations. These findings underscore the necessity of incorporating physical and psychological components into education and health strategies. The study offers theoretical uniqueness through the establishment of a cross-disciplinary structural model that bridges sport science, psychology, and education, specifically within the Indonesian high school environment.

However, this study has major drawbacks. The cross-sectional design does not allow for causal inference, and the dependence on self-reported metrics may add potential bias. Future studies should use longitudinal or experimental approaches and broaden sampling across broader demographics to validate these results. Overall, this research contributes to a more comprehensive picture of student development and opens routes for further investigations into the connection between physical behavior, psychological well-being, and academic outcomes.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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