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From Sedentary Behavior to Early Non-Communicable Disease Risk: The Protective Role of Physical Fitness among Students

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A B S T R A C T

Sedentary lifestyle among students is increasingly prevalent and is associated with decreased physical fitness and a higher risk of early non-communicable diseases (NCDs). This study used a systematic literature review following PRISMA guidelines by analyzing observational and experimental studies from reputable databases. The results indicate that sedentary behavior significantly reduces cardiorespiratory fitness and muscular strength and increases the risk of obesity, metabolic disorders, and cardiovascular diseases, while higher physical fitness levels act as a protective factor. Therefore, reducing sedentary lifestyle through increased physical activity from an early age is an important preventive strategy to lower the long-term risk of NCDs.

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INTRODUCTION

Changes in modern lifestyles characterized by increased sitting duration, excessive use of gadgets, and low involvement in physical activity have led to an increase in sedentary lifestyles in school students, where this behavior involves long sitting or lying down time and high screen time consumption. Scientific evidence suggests that sedentary behavior is significantly correlated with decreased physical fitness in children, including cardiorespiratory function and poor body composition, as well as being susceptible to increased body fat as a long-term health risk factor (Prince et al., 2024; Mappanyukki et al., 2024).

International research also reveals that reduced physical activity and increased sedentary behavior contribute to a reduction in cardiorespiratory fitness and other fitness parameters in the school-age population (Dunstan, 2021). Furthermore, local empirical evidence confirms the existence of a negative relationship between the level of sedentary lifestyle and the physical fitness of students, where the increase in the duration of inactivity is inversely proportional to the overall physical fitness score (Syam, 2024).

A decline in physical fitness from an early age is significantly associated with increased risk factors for Non-Communicable Diseases (NCDs) such as obesity, type 2 diabetes mellitus, and cardiovascular disease later in life. Longitudinal research shows that low levels of cardiorespiratory fitness (a major component of physical fitness) in childhood and adolescence are associated with increased body mass index (BMI), body fat, and the incidence of metabolic syndrome in adulthood, which are key indicators of obesity and NCD risk (Mintjens et al., 2018). Meta-analysis evidence also suggests that a decreased physical fitness component at a young age correlates with poor cardiometabolic health profiles such as insulin resistance and obesity, which are risk factors for type 2 diabetes and heart disease (Visser et al., 2024).

NCDs, which were previously dominant in adulthood, now show a significant increase in the age group of children and adolescents, where behavioral factors such as sedentary lifestyles, unhealthy diets, and sedentary behaviors contribute to the development of NCD risk from adolescence to adulthood (Akseer et al., 2020). These risk behaviors, particularly low physical activity and prolonged sitting habits, have been identified as key components associated with obesity, hypertension, and other comorbidities in adolescents, thus making NCDs a serious public health issue (Biswas et al., 2022).

Schools as the main environment of students have a strategic role in promotive and preventive interventions through policies and facilities that encourage physical activity and reduce sedentary behavior, which has been shown to have an effect on the level of physical activity and its intensity (Sales et al., 2023). School-based interventions such as structured physical activity programs and health promotion have been shown to be effective in lowering risk factors for NCDs and improving physical fitness in children and adolescents, thus demonstrating the importance of the role of schools in public health strategies (Nguyen, 2025).

Most of the research to date still focuses on the relationship between physical activity, sedentary behavior, and non-communicable diseases in the

adult population, so a comprehensive study in the school-age group is still limited and not comprehensive (Andriyani et al., 2020). Research that integrates three main aspects, namely sedentary behavior, physical fitness, and early risk of NCDs in children and adolescents, is often reported separately without systematic synthesis, so the picture of the causal relationship and protective mechanisms of physical fitness to NCD risk from school age is unclear (Hanifah et al., 2023).

This study aims to analyze the relationship between sedentary lifestyle and physical fitness level in students by referring to empirical findings from previous research. In addition, this study examines the role of physical fitness as a protective factor in reducing the risk of early non-communicable diseases (NCDs) in school-age groups. This study also identifies key factors that have the potential to strengthen or weaken the relationship between sedentary behavior and NCD risk, both individual and environmental. Furthermore, the results of the research are expected to formulate school-based preventive implications and provide a scientific basis for the development of health and education policies oriented towards the implementation of an active lifestyle among students.

THEORETICAL REVIEW

A review of the literature that places physical fitness as a protective factor for the development of NCDs in childhood is still rare, as are studies that highlight school-based preventive approaches and their implications for health and education policies (Andriyani et al., 2020). Finally, differences in methods of measuring sedentary behavior and physical fitness in various studies led to significant variation in results, which demanded standardized methods to be able to produce a more consistent and comprehensive picture (Andriyani et al., 2020).

The literature review method is a research approach that allows the collection, evaluation, and synthesis of empirical findings from various different studies in a comprehensive manner so as to provide a comprehensive picture of the phenomenon being studied and identify research gaps and patterns of relationships between variables (Paré et al., 2015). The preventive approach in the scientific literature emphasizes the orientation on early prevention and identification of key risk factors, rather than simply addressing the impact of the problem, thus being able to form an analytical framework that focuses on early intervention. Thus, the literature review helps identify patterns of relationships between risk factors and potential intervention gaps in the student context, which can be used as the basis for the formulation of promotive and preventive strategies. Furthermore, this method efficiently strengthens the theoretical basis and scientific evidence without the time and cost constraints of field research, so that evidence-based recommendations can be formulated for follow-up research and policy (Paré et al., 2015).

METHODOLOGY

This study uses the design of Systematic Literature Review (SLR) or systematic literature review which aims to identify, evaluate, and synthesize

scientific evidence related to the relationship between sedentary lifestyle, physical fitness level, and early risk of non-communicable diseases (NCDs) in students. The SLR approach was chosen because it is able to present a comprehensive, objective, and structured picture of behavioral risk factors and the role of physical fitness as a preventive effort for NCDs from school age based on the results of various primary studies. All stages of systematic review are carried out with reference to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency, methodological validity, and reproducibility of research results.

Literature search is carried out systematically through several electronic databases, namely PubMed, Scopus, Web of Science, ScienceDirect, and Google Scholar. The article search strategy uses a combination of keywords relevant to the research topic as well as the Boolean AND and OR operators as follows:

1. "Sedentary lifestyle" OR "Sedentary behavior" OR "Physical inactivity"
2. "Physical fitness" OR "Cardiorespiratory fitness" OR "Fitness level"
3. “Non-communicable diseases” ATAU “Metabolic risk” ATAU “Cardiovascular risk”
4. "Students" OR "Children" OR "Adolescents"
5. "Prevention" OR "Early risk"

Articles included in this study are limited to publications of the last five years (2020–2025) to ensure that the synthesis of research results reflects up-to-date scientific evidence and is relevant to recent developments in the field of public health and child health.

The article selection process was carried out by two independent reviewers through the title and abstract screening stage based on the inclusion and exclusion criteria that have been set. Inclusion criteria include:

1. Studies that address sedentary lifestyle, physical fitness, and/or NCD risk in students or adolescents;
2. Research with observational or experimental design;
3. Articles published in reputable scientific journals and are available in full text.

Exclusion criteria include articles that are not relevant to the student population, non-systematic review articles, case reports, editorials, as well as publications that are not fully accessible. Articles that pass the initial screening stage are then reviewed in full (full-text review) to assess the suitability of focus and methodological quality. If there are differences in assessment between reviewers, discussions are held to reach consensus, and if necessary involve a third reviewer.

Data extraction was carried out systematically on all articles that met the inclusion criteria by covering the following variables:

1. Author's name, year of publication, and country of research
2. Research design and sample characteristics (age, gender, and number of respondents)
3. Sedentary lifestyle indicators used (sitting duration, screen time, or daily physical activity)

4. Measured physical fitness parameters (cardiorespiratory fitness, muscle strength, or fitness index)
5. Types and risk indicators of non-communicable diseases (obesity, metabolic syndrome, blood pressure, or blood glucose)
6. Key findings of the study are related to the relationship between sedentary lifestyle, physical fitness, and risk of early NCDs

The literature selection process was reported using the PRISMA flowchart which depicted the number of articles identified, screened, assessed for eligibility, as well as the number of studies that were finally included in the final synthesis. This diagram provides a clear visualization of the selection stages and the reasons for article exclusion, thereby increasing the transparency and accountability of the research process.

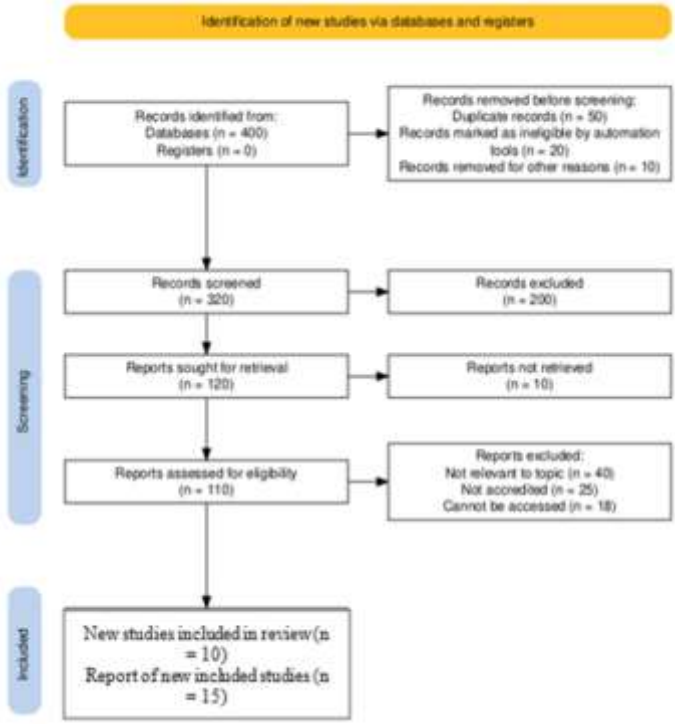

Figure 1. Diagram PRISMA

This PRISMA diagram illustrates the literature selection process in a systematic review of the latest developments in the diagnosis and therapeutic management of synanasal carcinoma. Of the total 400 articles obtained through database search, 80 were removed before the screening stage due to duplication (50), did not meet the criteria through automation tools (20), or were removed for other reasons (10). A total of 320 articles were continued to the initial screening stage. After the title and abstract screening process, 200 articles were removed for not meeting the inclusion criteria, and 120 articles were evaluated at the full-text search stage. Of the 120 articles, 10 full-text reports were inaccessible, so 110 articles could be assessed for eligibility. At the feasibility assessment stage, 83 articles were excluded because they were not relevant to the focus of the study (40), did not have adequate publication quality (25), or were not fully accessible

(18). In the end, a total of 10 studies were declared eligible and included in the final synthesis of this systematic review. This step-by-step process ensures that only relevant, valid, and high-quality research is used as the basis for the analysis.

Data analysis was carried out qualitatively using the narrative synthesis method. The findings of each article are classified into main themes, namely:

1. The relationship between sedentary lifestyle and the level of physical fitness in students;
2. The effect of sedentary lifestyle on the risk of early NCDs;
3. The role of physical fitness as a protective factor against the risk of NCDs; and
4. School-based preventive implications in reducing sedentary behavior and NCD risk.

The results of the synthesis are presented in the form of a narrative description that is reinforced with a table of study characteristics to facilitate comparisons between studies and identify patterns, consistency, and gaps in existing scientific evidence.

RESEARCH RESULTS

Search Strategies

The Literature search strategy is carried out systematically through major electronic databases such as PubMed, Scopus, Web of Science, ScienceDirect, and Google Scholar with a combination of keywords relevant to the research topic. Key keywords include: "sedentary lifestyle", "physical fitness", "students", "non-communicable diseases", "physical activity", and other related terms combined using Boolean AND/OR operators to expand the scope of the search. The search is focused on primary research articles published in the last five years (2020–2025) to ensure the relevance and novelty of the findings. In addition, tracing is also carried out through reference list scanning of found articles to capture studies that have high relevance but were not identified in the initial search.

The initial results of the search yielded hundreds of scientific articles. Next, a strict screening process of titles and abstracts is carried out based on the inclusion and exclusion criteria that have been set, then continues with a full-text review to assess the methodological suitability and suitability of the content with the focus of the research. This process ensures that all articles included in the synthesis are truly relevant to the relationship between sedentary lifestyle, physical fitness, and non-communicable disease risk in the student population.

Quality Assessment and Risk of Bias

Each article that passed the selection was checked for methodological quality to ensure the validity of the findings reviewed. Quality assessment is based on several aspects, namely: clarity of the research design, definition of variables, sedentary lifestyle and physical fitness measurement techniques, control of confounders, and statistical results reporting. Articles that do not meet minimum quality standards, such as a lack of methodological explanations or unclear variable sizes, are eliminated from the final synthesis.

The risk of bias was examined by paying attention to the research design used. Studies with cross-sectional designs face the risk of temporal bias and causality due to data collection at a single point in time, while studies using a combination of objective measuring instruments (e.g. accelerometers) have a lower risk of measurement bias than studies using questionnaire-only. All articles are also adjusted to reporting standards to reduce reporting bias and improve the reliability of research synthesis results.

Article Screening Results

The following are 10 primary journals that were reviewed based on research criteria related to sedentary lifestyle, physical fitness, and health risks in relevant students/children/adolescents:

Table 1. Screening Results of Articles Related to Sedentary Lifestyle, Physical Fitness, and Health Risks in Students

Yes	Author	Study Design	Population	Focus/Intervention	Key Findings
1	Dwi Andriyani et al., 2023 (Indonesia)	Mixed-method case study	5 young men 14–15 years old	Physical activity & sedentary behavior	Sedentary time is predominantly high; light physical activity predominates; high sedentary behavior patterns during the pandemic
2	Zheng et al., 2016 (China)	*Cross-sectional*	770 children aged 9–12 years	Sedentary + physical activity & dyslipidemia	High screen time associated with the risk of dyslipidemia in boys; Low physical activity is associated with an increased risk
3	Syam, 2024 (Indonesia)	*Correlational*	31 elementary school students aged 10-12 years old	Sedentary lifestyle vs kebugaran jasmani	Significant negative relationship between sedentary lifestyle and

					physical fitness
4	Unesa et al., 2022 (Indonesia)	*Cross-sectional*	105 students of SMAN 1 Kebomas Gresik	Healthy lifestyle vs physical fitness	No significant association was found between a healthy lifestyle and physical fitness
5	Andriyani et al., 2021 (Indonesia)	*Qualitative*	20 teenage parents	Changes in physical activity & sedentary behaviour	Pandemic impact: physical activity decreases, sedentary behavior increases
6	Zheng et al., 2016 (China)	*Cross-sectional*	770 school-age children	Screen time & metabolic health	High screen time associated with heart health risks
7	Guo et al., 2022 (China)	*Cross-sectional*	512 female students	SB & physical fitness	Negative sedentary time is associated with the fitness component
8	Sánchez-Delgado et al., 2021 (Spanish)	Longitudinal	Children & Teens Ages 6-15	SB & physical components	SB is associated with the risk of MetS through obesity
9	Saputra & Arief, 2025 (Indonesia)	Quantitative students	School population	Screen time & obesitas risk	Sedentary lifestyle is associated with obesity risk in students
10	Reimers et al, 2012 overall	Review epidemiology	Global school population	Physical activity & NCDs	Low physical activity is associated with NCD risk from a young age

Based on the results of the interpretation of the literature reviewed, in general, it was found that there was a pattern of relationship between sedentary

behavior, physical fitness, and health risks in children and adolescents, although the findings varied between studies. High sedentary behaviors, especially increased sitting time and screen time, are negatively associated with physical fitness, characterized by decreased cardiorespiratory components and muscle strength in elementary school-age students, as shown by a significant negative correlation in the study of Syam (2024). In addition, sedentary behavior and screen time also contribute to increased metabolic health risks, such as dyslipidemia and metabolic syndrome (MetS), although the magnitude of the relationship is influenced by activity type, gender, and social context, including an increase in sedentary behavior during the COVID-19 pandemic accompanied by a decrease in physical activity. However, not all studies have shown a significant association between sedentary behavior and physical fitness, indicating the presence of other mediating factors, such as diet, academic load, and differences in measurement methodology, so these relationships need to be understood more comprehensively and contextually.

DISCUSSION

The results of the literature review show that sedentary lifestyle is the dominant behavior that is increasingly found in students and adolescents, especially since the change in activity patterns during the pandemic. Qualitative and mixed-method studies in Indonesia revealed that sedentary time in adolescents is more spent on passive sitting activities with the dominance of screen-based activities (Dwi Andriyani et al., 2023; Andriyani et al., 2021). These findings are in line with the results of cross-country research showing that low physical activity has become a global pattern in the school-age population (Reimers et al., 2012). This condition shows a shift in an active lifestyle towards sedentary behavior from an early age. If left unchecked, this pattern of behavior has the potential to continue into adulthood. Therefore, a sedentary lifestyle needs to be seen as an initial risk factor in the context of student health.

The relationship between sedentary lifestyle and physical fitness is one of the main focuses in the reviewed study. Correlation studies in elementary school students show a significant negative relationship between sedentary behavior and physical fitness levels, where the higher the sedentary time, the lower the physical fitness of students (Syam, 2024). Similar results were also found in the student population, which suggests that sedentary time is negatively related to physical fitness components such as endurance and muscle strength (Guo et al., 2022). However, other studies at the high school level have found no significant association between a general healthy lifestyle and physical fitness (Unesa et al., 2022). These differences in results indicate variations in context, age, and fitness measurement indicators. Thus, sedentary behavioral factors need to be analyzed specifically and not equated with the concept of a healthy lifestyle in general.

In addition to having an impact on physical fitness, a sedentary lifestyle also contributes to an increased risk of non-communicable diseases (NCDs) from school age. Cross-sectional research in China shows that high screen time is significantly associated with the risk of dyslipidemia and metabolic health disorders in children, especially in boys (Zheng et al., 2016). These findings are

reinforced by another study that states that excessive screen time exposure is associated with an increased risk of heart health in school-age children (Zheng et al., 2016). In Indonesia, recent research shows that sedentary lifestyle has a strong association with the risk of obesity in students (Saputra & Arief, 2025). Obesity conditions in children are the main risk factors for NCDs such as diabetes mellitus and cardiovascular disease. Therefore, controlling sedentary behavior is an important part of efforts to prevent early NCDs.

Longitudinal evidence suggests that the impact of sedentary behavior is not only short-term, but also contributes to long-term health risks. A longitudinal study in Spain found that sedentary behavior is associated with an increased risk of metabolic syndrome through mechanisms of increased obesity in children and adolescents (Sánchez-Delgado et al., 2021). These findings confirm that the accumulation of sedentary time can trigger gradual metabolic changes. This is in line with the epidemiological view that low physical activity from school age is an early determinant of NCDs (Reimers et al., 2012). Thus, the prevention of sedentary behavior cannot be postponed until adulthood. Intervention from school age becomes a more effective and sustainable strategy. Schools have a strategic role in breaking the chain of risk.

The differences in findings between studies also reflect the complexity of factors that affect students' fitness and health risks. Environmental factors, family support, school policies, and digital habits also mediate the relationship between sedentary lifestyle and physical health (Andriyani et al., 2021; Dwi Andriyani et al., 2023). In addition, variations in study design, sample size, and measurement indicators also affect the results of the study (Unesa et al., 2022). Nevertheless, the majority of empirical evidence points to a consistent direction of the relationship between sedentary behavior and decreased fitness and increased health risks (Syam, 2024; Guo et al., 2022). This confirms the importance of a multidimensional approach in understanding the phenomenon. Thus, the preventive literature review provides a solid basis for integrating various empirical findings. This approach is relevant in the context of student health which is complex and dynamic in nature.

Overall, the results of the literature review show that sedentary lifestyle is an important determinant that contributes to decreased physical fitness and increased risk of premature non-communicable diseases in students. Empirical evidence from various national and international contexts confirms that sedentary behaviors, especially excessive screen time, have significant health implications from school age (Zheng et al., 2016; Sánchez-Delgado et al., 2021). Although there was variation in outcomes between studies, the dominant relationship direction showed a consistent risk trend. Therefore, a preventive approach through increased physical activity and control of sedentary behavior is very important. Schools are seen as strategic environments for evidence-based promotive and preventive interventions. These findings provide a strong theoretical and empirical basis for further research and formulation of school health policies oriented towards the prevention of NCDs from an early stage.

CONCLUSIONS AND RECOMMENDATIONS

This study concludes that sedentary lifestyle is a significant risk factor for decreased physical fitness and increased risk of non-communicable diseases. The majority of the articles reviewed showed a consistent association between high sitting duration and decreased cardiorespiratory capacity and muscle strength. Sedentary behavior also contributes to metabolic disorders such as obesity, type 2 diabetes mellitus, and cardiovascular disease. These findings reinforce the evidence that low physical activity has a direct impact on an individual's health status. Thus, sedentary lifestyle needs to be seen as a serious public health issue. The results of the study also show that the level of physical fitness plays a protective factor against the negative impact of sedentary behavior. Individuals with adequate levels of physical activity tend to have a lower risk of disease despite being exposed to sedentary behaviors for a certain duration. Variations in sedentary behavior and physical fitness measurement methods are a challenge in comparing results between studies. Nevertheless, the consistency of the direction of the findings strengthens the validity of the conclusions of this study. Therefore, improving physical fitness is an important strategy in mitigating health risks due to a sedentary lifestyle.

FURTHER STUDY

Further research needs to focus on the use of sedentary lifestyle and physical fitness measurement instruments that are more objective, standardized, and technology-based to improve data accuracy. In addition, longitudinal and experimental studies are needed to clarify the causal relationship between sedentary behavior, physical fitness level, and risk of non-communicable diseases. Intervention research that focuses on increasing physical activity in school and community settings is also important to evaluate the effectiveness of sedentary lifestyle prevention strategies. The expansion of the research population across different age groups, genders, and sociocultural backgrounds is expected to produce more comprehensive findings and support evidence-based health policy formulation.

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