

# The relationship between physical activity and the risk of diabetes mellitus in elementary school children (ages 8–12 years)

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## ABSTRACT

The rapid advancement of technology and shifts in modern lifestyles have led young children to spend more time indoors engaging with electronic devices, consequently reducing their physical activity levels. Insufficient physical activity during early childhood is considered a potential risk factor for developing Diabetes Mellitus (DM). This study aimed to investigate the relationship between physical activity and the risk of DM among elementary school children aged 8–12 years. A cross-sectional quantitative design was employed in May 2025 at SDN Tasikmadu 1 Malang, involving 154 participants within the specified age range. Data were analyzed using the Chi-Square test. The results indicated that 84.4% of the children demonstrated a moderate level of physical activity, while 15.6% exhibited a high level. Regarding diabetes risk, 43.5% were classified as moderate risk, 37.0% as low risk, and 19.5% as high risk. Statistical analysis revealed no significant association between physical activity and diabetes risk ( $p = 0.294$ ,  $p > 0.05$ ). In conclusion, there was no statistically significant relationship between physical activity and DM risk among the studied population. Nevertheless, regular monitoring and the promotion of physical activity remain essential to support overall child health and reduce the likelihood of future metabolic disorders.

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## INTRODUCTION

The rapid advancement of technology and modernization has brought both positive and negative impacts on children's daily lives. In this digital era, many children spend more time indoors using electronic devices such as mobile phones, computers, and televisions. This situation limits their opportunities to play outdoors and engage in physical activities. Physical activity is an essential part of a healthy lifestyle and plays a significant role in supporting children's physical growth, cognitive abilities, and social development. However, modernization has led to a decrease in

children's involvement in outdoor play, resulting in reduced levels of physical activity (Ningsih, 2024; World Health Organization [WHO], 2010, 2022).

Diabetes Mellitus (DM) is a chronic metabolic disorder characterized by high blood glucose levels due to abnormalities in insulin secretion, insulin function, or both (World Health Organization, 2019; American Diabetes Association, 2020). Globally, DM cases continue to rise, affecting not only adults but also children and adolescents. In Indonesia, the number of diabetes cases among children has increased sharply from 2000 to 2023. According to the Indonesian Pediatricians Association (IDAI), there were 1,220 children diagnosed with type 1 diabetes in 2018. Between 2000 and 2010, the incidence of diabetes among children increased almost sevenfold, from 3.88 to 28.19 per 100 million people. The Indonesian Doctors Association (IDI) also reported in January 2023 that diabetes cases in children had increased seventyfold compared to 2010, reaching two cases per 100,000 children (Utomo, 2020).

More recent empirical data have shown a concerning rise in type 2 diabetes mellitus (T2DM) cases among children and adolescents in Indonesia. According to the Indonesian Pediatric Society (IDAI, 2023), approximately 30–40% of newly diagnosed diabetes cases in children are now classified as type 2, a condition previously rare in this age group. This trend is attributed to increasing rates of childhood obesity, sedentary lifestyles, and excessive screen time, especially in urban populations. Studies conducted in Jakarta, Surabaya, and Yogyakarta between 2021 and 2024 have reported that children who engage in less than 60 minutes of moderate-to-vigorous physical activity per day are at significantly higher risk of insulin resistance and prediabetes (Widyastuti et al., 2023; Kurniawan & Pramesti, 2024). This evidence underscores the urgency of preventive efforts focusing on physical activity in school-aged populations.

The increasing prevalence of diabetes among children is closely related to lifestyle changes, particularly low levels of physical activity and increased screen time. Many children prefer to spend their leisure time playing with gadgets rather than engaging in physical games that require movement (Anri, 2022; Purwandari, 2020b). In urban areas such as Malang, several environmental, social, and behavioral factors further contribute to reduced physical activity. Limited access to safe playgrounds, traffic congestion, and air pollution discourage outdoor play. Socially, the growing emphasis on academic achievement and extracurricular tutoring reduces children's free time for physical exercise. Behaviorally, easy access to digital entertainment, coupled with parental perceptions that indoor activities are safer, fosters sedentary habits (Hidayat, 2023; Suwandi et al., 2022).

Physical activity helps regulate blood glucose levels by enhancing insulin sensitivity and promoting glucose uptake by muscle cells (Putra, Rahayu, & Suryani, 2019; Purwandari, 2020a). When a person engages in regular physical activity, the working muscles require more energy, which encourages the cells to use glucose more efficiently. This process reduces the amount of glucose circulating in the blood and prevents excessive fat storage. Physical activity also improves blood circulation, stimulates insulin receptors, and strengthens metabolic function (Faulkner et al., 2020; Ekelund et al., 2019). Conversely, children who rarely exercise tend to have higher blood sugar levels, fat accumulation, and poor metabolism, which can trigger early symptoms of Diabetes Mellitus (Nadia, Putri, & Wulandari, 2019).

Considering the emerging data and urban lifestyle challenges, early intervention through school-based and community-level programs is urgently needed. Promoting physical activity, creating safe play environments, and limiting screen time are essential strategies to prevent metabolic diseases from early childhood.

Based on these considerations, it is important to examine the relationship between physical activity and the risk of Diabetes Mellitus in children. Early interventions through education and lifestyle modification can help prevent diabetes from an early age (Firnanda, Nuzil, Salsabila, & Khoiriyah, 2023). Therefore, this study aims to determine the relationship between physical activity and the risk of Diabetes Mellitus among elementary school children aged 8–12 years at SDN Tasikmadu 1 Malang. The findings of this research are expected to provide scientific evidence to support school-based health promotion programs, raise awareness about the importance of

physical and mental health, and guide preventive strategies in community and nursing practice (Notoatmodjo, 2012; Nursalam, 2020; Dahlan, 2016).

## RESEARCH METHOD

The study applied a quantitative non-experimental research design with a cross-sectional approach aimed at identifying the relationship between physical activity and the risk of Diabetes Mellitus among elementary school children. Data were collected from primary sources using validated instruments, including the Physical Activity Questionnaire for Older Children (PAQ-C) to assess students' physical activity levels and the Finnish Diabetes Risk Score (FINDRISC) to estimate the risk of diabetes, complemented by Body Mass Index (BMI) measurements for anthropometric assessment. In addition, secondary data from relevant books, journals, and official health reports were used to support and validate the findings. The study population comprised 154 students aged 8–12 years (grades 2–6) at SDN Tasikmadu 1 Malang City, from which all respondents meeting the inclusion criteria were selected using a total sampling technique. Inclusion criteria required students to be actively enrolled, within the specified age range, able to complete the questionnaire, and willing to participate with parental consent, while exclusion criteria included absence due to illness or voluntary withdrawal from the study. Data collection was conducted on-site in May 2025 through supervised questionnaire sessions and direct BMI measurements using calibrated equipment. Collected responses were coded, tabulated, and analyzed statistically using the Chi-Square ( $\chi^2$ ) test to determine the correlation between physical activity levels and diabetes risk, with a significance level of  $p \leq 0.05$ . The study ensured validity through the use of standardized and previously tested instruments (Kowalski et al., (2004); FINDRISC) and maintained ethical compliance by obtaining informed consent, ensuring confidentiality, and allowing voluntary participation. All findings were systematically interpreted to provide reliable, evidence-based insights aligned with the research objectives.

## RESULTS AND DISCUSSIONS

### Respondent Characteristics Data

**Table 1.** Distribution of elementary school students' characteristics based on gender, grade level, and age at SDN Tasikmadu 1 Malang City

| Characteris | Number of respondents | Presentase (%) |
|-------------|-----------------------|----------------|
| Age         | 8 Year                | 9.7            |
|             | 9 Year                | 29.9           |
|             | 10 Year               | 30.5           |
|             | 11 Year               | 14.9           |
|             | 12 Year               | 14.9           |
| Gender      | Male                  | 39.6           |
|             | Female                | 60.4           |
| Class       | 2                     | 16.2           |
|             | 3                     | 27.9           |
|             | 4                     | 32.5           |
|             | 5                     | 11.0           |
|             | 6                     | 12.3           |
|             | IMT                   | Underweight    |
| Normal      |                       | 58.4           |
| Overweight  |                       | 22.7           |

Based on Table 4.1, the majority of respondents in this study were female, totaling 93 students (60.4%). Most respondents were in grade 4, with 50 students (32.5%), and the largest age group was 10 years old, comprising 47 students (30.5%). Furthermore, the majority of respondents had a normal Body Mass Index (BMI) category, with 90 students (58.4%), indicating that most participants were within the healthy weight range according to BMI classification.

### Psychological Physical Activity Among Students of SDN Tasikmadu 1 Malang City

**Table 2.** Frequency distribution based on physical activity among elementary school children (aged 8-12 years) in may 2025

| Variable          | Category | Frequency | Percent |
|-------------------|----------|-----------|---------|
| Physical Activity | Moderate | 130       | 84.4    |
|                   | High     | 24        | 15.6    |

The study found that among elementary school students aged 8-12 years at SDN Tasikmadu 1 Malang City, the majority exhibited moderate physical activity levels, accounting for 84.4% of respondents. Meanwhile, only 15.6% of students demonstrated high levels of physical activity, and none were categorized as having low activity levels. This distribution indicates that while most children engage in some form of regular movement, their activity intensity and duration may not meet the recommended standards for optimal health. The prevalence of moderate activity reflects a lifestyle pattern influenced by limited opportunities for outdoor play and increasing engagement with electronic devices. Factors such as a heavy academic load, reduced physical education hours, and the availability of sedentary entertainment (television, smartphones, and online games) also contribute to insufficient physical activity among school-aged children.

Physical inactivity among children has been recognized as one of the key modifiable risk factors for the early onset of type 2 Diabetes Mellitus (DM) and other metabolic disorders. According to the World Health Organization (WHO, 2022), children aged 5-17 years are recommended to engage in at least 60 minutes of moderate to vigorous physical activity per day to maintain a healthy metabolic profile. However, technological dependence and urban living have reduced children’s daily movement, leading to decreased energy expenditure and increased fat accumulation. (D. Purwandari, 2020b) explains that limited physical activity reduces insulin sensitivity, causing glucose to remain in the bloodstream rather than being converted into energy. Similarly, Putra & Nugraha (2019) found that children with less than three sessions of outdoor play per week had a 1.7 times higher risk of insulin resistance compared to their more active peers. Hermayetty et al., (2021) also reported that sedentary behavior among elementary students is associated with higher BMI and early signs of metabolic syndrome. These findings align with the present study, highlighting the urgent need for schools and parents to encourage daily physical activity as a preventive measure against diabetes and obesity in children.

### Risk of Diabetes Mellitus Among Students of SDN Tasikmadu 1 Malang City

**Table 3.** Frequency distribution based on the risk of diabetes mellitus among elementary school children (aged 8-12 years)

| Variabel                  | Variable | Frequency | Percent |
|---------------------------|----------|-----------|---------|
| Risk of Diabetes Mellitus | Low      | 57        | 37.0    |
|                           | Moderate | 67        | 43.5    |
|                           | High     | 30        | 19.5    |

The study found that among elementary school students aged 8-12 years at SDN Tasikmadu 1 Malang City, the majority were categorized as having a moderate risk of Diabetes Mellitus (43.5%), followed by low risk (37.0%), and high risk (19.5%). This distribution suggests that nearly half of the children possess moderate susceptibility to diabetes, which may be influenced by lifestyle habits such as irregular eating patterns, limited physical activity intensity, and insufficient engagement in structured exercise. Although most respondents fall within the moderate-risk group, the presence of nearly one-fifth classified as high risk indicates early warning signs of potential metabolic imbalance. Factors such as inadequate physical activity, excessive screen time, consumption of high-sugar snacks, and genetic predisposition could contribute to elevated diabetes risk among this age group. The findings imply that preventive measures are necessary to promote balanced diets, active lifestyles, and regular medical screening for early detection of metabolic disorders.

From a theoretical perspective, these results align with prior studies emphasizing the strong correlation between childhood lifestyle behaviors and early-onset diabetes. Purwandari, (2020) notes that moderate to high DM risk in children often stems from sedentary behavior and unbalanced nutrition, which reduce insulin sensitivity and impair glucose metabolism. Similarly, A. R. Putra et al. (2019) and Hermayetty et al., (2021) found that children who spend more than three hours daily on screen-based activities without engaging in moderate physical exercise are twice as likely to experience elevated fasting glucose levels. The World Health Organization (WHO, 2022) highlights that children failing to meet the daily minimum of 60 minutes of moderate-to-vigorous activity face a significantly higher likelihood of obesity-related diabetes. Moreover, Anderson et al. (2021) and Kirk et al. (2023) explain that insufficient physical activity weakens glucose uptake due to reduced GLUT-4 protein expression, lowering muscle insulin sensitivity and increasing the risk of hyperglycemia. Collectively, these findings underscore the importance of early intervention through structured physical activity, health education, and nutritional guidance in school settings to mitigate diabetes risk among elementary-aged children.

### The Relationship Between Physical Activity and the Risk of Diabetes Mellitus Among Elementary School Children (Aged 8-12 Years)

**Table 4.** The relationship between physical activity and the risk of diabetes mellitus among elementary school children (aged 8-12 years) in may 2025

| Aktivitas Fisik | Low        | Moderate   | High       | Total | P value               |
|-----------------|------------|------------|------------|-------|-----------------------|
| Moderate        | 46 (35.4%) | 56 (43.1%) | 28 (21.5%) | 130   | 0.294<br>(Chi-Square) |
| High            | 11 (45.8%) | 11 (45.8%) | 2 (8.3%)   | 24    |                       |
| Total           | 57 (37.0%) | 67 (43.5%) | 30 (19.5%) | 154   |                       |

The study found that among students aged 8-12 years at SDN Tasikmadu 1 Malang City, the majority (84.4%) demonstrated moderate physical activity levels, while only 15.6% showed high levels of physical activity. Based on the analysis of diabetes risk categories, 43.5% of students were classified as having moderate risk, 37.0% as low risk, and 19.5% as high risk. The Chi-Square test yielded a p-value of 0.294 ( $p > 0.05$ ), indicating that there was no statistically significant relationship between physical activity levels and the risk of Diabetes Mellitus among the respondents. Although most students were classified as moderately active, their activity duration and intensity were insufficient to produce optimal metabolic benefits. The findings suggest that daily movements such as walking to school, recess activities, and informal play contribute to moderate physical activity but may not be enough to effectively reduce diabetes risk. Structured and consistent physical exercise remains limited among students, highlighting the need for more organized activity programs within the school environment.

From a theoretical perspective, this finding aligns with previous studies showing that moderate activity without sufficient intensity or duration may fail to produce significant metabolic improvements. H. Purwandari (2020) explained that while physical activity enhances insulin sensitivity, the benefits depend on exercise regularity and energy expenditure. Similarly, R. Putra & Nugraha (2019) found that children engaging in structured aerobic activities at least three times a week had significantly lower fasting glucose levels compared to those who only participated in spontaneous play. The World Health Organization (WHO, 2022) recommends at least 60 minutes of moderate-to-vigorous physical activity daily, including activities such as running, cycling, or swimming, to maintain optimal metabolic function. However, the findings from SDN Tasikmadu 1 indicate that most students' activity patterns are unstructured, short in duration, and low in intensity. This pattern limits the physiological effects of physical activity on glucose regulation. Anderson et al. (2021) noted that exercise lowers blood glucose through mechanisms such as increased GLUT-4 protein expression and improved fatty acid oxidation, while Kirk et al. (2023) emphasized that the effectiveness of physical activity depends not only on frequency but also on duration, intensity, and consistency. These theoretical insights support the current results, suggesting that while physical activity plays a crucial role in diabetes prevention, unstructured and

inconsistent activity patterns may not be sufficient to significantly reduce diabetes risk in school-aged children.

## CONCLUSION

This quantitative cross-sectional study revealed that the relationship between physical activity and the risk of type 2 Diabetes Mellitus (DM) among elementary school students is shaped by complex behavioral and environmental factors rather than exercise frequency alone. The findings emphasize that while most children are moderately active through daily movements, their activities often lack sufficient structure, duration, and intensity to yield optimal metabolic benefits. This condition reflects the influence of modern lifestyles, where increased gadget use, limited outdoor spaces, and reduced engagement in structured sports contribute to sedentary behavior and early metabolic vulnerability. The results reinforce theoretical perspectives from WHO, Purwandari, and Anderson et al., which highlight that the quality and consistency of physical activity are more decisive in improving insulin sensitivity and glucose regulation than the amount of movement performed. Socially and culturally, the study underscores the need for integrated school-based health promotion strategies that encourage structured physical education and balance technology use with active play. Academically, it contributes empirical evidence supporting the inclusion of standardized assessment tools such as PAQ-C and FINDRISC in early health screening to identify potential risks among children. In practical terms, schools and health workers can play a crucial role in increasing children's physical activity in a structured and sustainable manner. Schools should integrate daily physical activity programs within the curriculum, not only through formal physical education classes but also through active breaks and extracurricular sports clubs. Collaboration with parents and local health centers can ensure consistent messaging about the importance of physical activity and healthy screen time management at home. Health workers, particularly school nurses and community health staff, should conduct regular monitoring of children's physical activity levels and provide educational workshops on active lifestyles, balanced nutrition, and early diabetes prevention. Additionally, creating supportive environments such as safe playgrounds, community-based exercise events, and 'car-free day' initiatives can foster long-term engagement in active behaviors. Despite its contributions, the study is limited by its focus on a single institution and reliance on self-reported data, which may reduce generalizability. Future research should expand to include multiple schools and diverse settings to capture regional and socioeconomic variations. Longitudinal designs are recommended to observe behavioral and metabolic changes over time, providing stronger causal evidence of how physical activity influences the onset of type 2 diabetes. Incorporating objective biomarkers such as fasting blood glucose, HbA1c, or insulin resistance indices would allow for a more accurate assessment of metabolic health and strengthen the validity of findings. Moreover, future studies could explore the role of psychosocial factors—such as motivation, parental influence, and digital habits in shaping children's physical activity behaviors, contributing to the development of more holistic and culturally relevant diabetes prevention models for Indonesian children.

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