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ARTICLE

Sedentary Behavior, Perceived Stress, and Depression among Adolescent Girls in Indonesia: A Cross-Sectional Study

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ABSTRACT: Background: Adolescent girls tend to engage in more sedentary behavior than boys, which is associated with adverse physical and psychosocial outcomes, including depression. This study examined the relationships between sedentary behavior, perceived stress, body mass index (BMI), and depressive symptoms among adolescent girls in Indonesia and tested the mediating roles of perceived stress and BMI. **Methods:** A cross-sectional survey was conducted among 482 female senior high school students (age 14–20) in Malang City, East Java, Indonesia. Sedentary behavior was assessed by the Adolescent Sedentary Activity Questionnaire (ASAQ) and expressed as total hours/day. Perceived stress was measured with the 10-item Perceived Stress Scale (PSS-10). Depression was measured by the Beck Depression Inventory-II (BDI-II). Descriptive statistics and Spearman correlations were computed. Parallel mediation analysis was conducted to examine indirect effects of perceived stress and BMI on the association between sedentary behavior and depressive symptoms, adjusting for age. **Results:** Participants' mean age was 16.24 (SD = 1.12) years, with a mean BMI of 20.62 (SD = 3.44). The average sedentary time was 9.38 (SD = 6.06) hours/day. The mean scores for depression and perceived stress were 10.44 (SD = 7.15) and 20.24 (SD = 5.19), respectively. Higher sedentary behavior was associated with higher perceived stress (β = 0.133, p = 0.010, f^2 = 0.051). Both BMI (β = 0.133, p = 0.005, f^2 = 0.031) and perceived stress (β = 0.392, p < 0.001, f^2 = 0.209) were positively associated with depression. Mediation analysis showed a significant indirect effect of sedentary time on depression through perceived stress (β = 0.052, 95% CI [0.014, 0.100]), whereas BMI did not mediate this relationship. **Conclusions:** Sedentary behavior is indirectly associated with depressive symptoms through increased perceived stress among adolescent girls. Interventions should integrate reductions in sedentary behavior and stress management to prevent adolescent depression.

KEYWORDS: Sedentary behavior; perceived stress; depression; adolescents

1 Introduction

Sedentary behavior is increasingly prevalent among adolescent girls and represents a serious public health concern. Sedentary behavior is generally described as activities that require low energy expenditure (≤1.5 metabolic equivalents (MET)), such as watching television, playing video games, sitting, or lying down [1]. In contrast, physical activity is any bodily movement that requires energy expenditure more than resting levels [2]. According to the World Health Organization (WHO), children and adolescents are

recommended to engage in at least 60 min of moderate-to-vigorous physical activity (MVPA) daily and minimize sedentary behavior [3]. However, global estimates indicate that approximately 81% of adolescents worldwide do not meet the recommended physical activity levels, thereby increasing their risk of sedentary behavior [4]. Adolescent girls are consistently reported to be less physically active than boys and are more likely to engage in sedentary behavior [3,5,6].

The excessive sedentary behavior was reported to be associated with poor mental health outcomes [3,6]. Chen et al. [6] found that girls with higher levels of sedentary behavior were more likely to report suicide-related behaviors compared to boys, reflecting greater emotional sensitivity and stress vulnerability. The increasing sedentary behavior also significantly increases the stress level and depression in university students [7]. A study of adolescents in 30 low- and middle-income countries has shown that those who engage in ≥8 h/day of sedentary behavior have higher odds of depression [2]. Prolonged sedentary time can cause serious mental health problems because it has been associated with reduced physical activity and participation in social interaction, leading to interpersonal relationships disruption, low self-esteem, and heightened psychological vulnerability [8–10]. Some studies indicate that sedentary behavior is independently associated with perceived stress and depressive symptoms [2,7,10]. However, studies that explored the mediating role of perceived stress linking sedentary behavior to depressive symptoms in adolescent girls remain limited.

Sedentary behaviors are significantly correlated with elevated body mass index (BMI). Previous studies show that adolescent girls demonstrate higher levels of sedentary behavior than boys, a trend associated with lower engagement in physical activity and higher BMI [11,12]. A study on adolescents in Saudi Arabia demonstrated that sedentary behavior in girls was positively associated with higher BMI score compared to boys [13]. The low energy expenditure in sedentary behavior does not significantly increase beyond rest levels, potentially creating metabolic dysregulation, which may contribute to the increasing adiposity [14]. Furthermore, elevated BMI has been linked to depressive symptoms in adolescents through body image dissatisfaction [15,16]. This phenomenon commonly happens among adolescent girls, for whom physical appearance plays an important role in maintaining psychological well-being [17]. Consequently, excessive sedentary behavior in adolescent girls can create a cycle of elevated BMI and lead to adverse mental health outcomes.

Addressing sedentary behavior and mental health aspects of adolescents is also closely aligned with the Sustainable Development Goals (SDGs), particularly SDG 3. Reducing sedentary behavior and stress aligns with SDG 3 priorities related to mental health promotion and lower early mortality from non-communicable diseases [18]. Intervention strategies that encourage physical activity, reduce screen time, and support stress management can help adolescent girls achieve better mental health outcomes, thereby contributing to a broader SDG agenda.

Previous observational and epidemiological studies have documented associations among sedentary behavior, BMI, perceived stress, and depressive symptoms [2,7,10,12]. However, limited research has examined whether BMI and perceived stress function as mediating mechanisms linking sedentary behavior to depression. The current study focused on adolescent girls because these factors are important and may influence mental and physical health during their developmental period. Accordingly, the primary purpose of this study was to determine the associations between sedentary behavior and depressive symptoms. Second, this study examined whether perceived stress and BMI mediated the association between sedentary behavior and depressive symptoms among adolescent girls. Understanding the complex relationship between sedentary behavior, perceived stress, and depression may help identify modifiable risk factors and

inform the development of targeted prevention and intervention strategies tailored to the specific needs of adolescent girls.

2 Methods

2.1 Study Participants

A cross-sectional study design was used to explore sedentary behavior and psychological conditions among adolescent girls. The minimum sample size was calculated using G*Power 3.1 [19]. The test family was established using linear multiple regression. The effect size (f^2) was set at 0.04, representing a small effect based on a prior behavioral study [20], a significance level (α) set at 0.05, and a minimum statistical power ($1 - \beta$) of 0.80. The model included three primary variables: sedentary behavior, BMI, and perceived stress, and depression as the dependent variable, with age included as a covariate. An additional 20% sample size was added to overcome the potential for incomplete questionnaires. Based on these parameters, the minimum sample size was 417.

The study population was drawn from public senior high schools in Malang City, East Java, Indonesia, with ten schools constituting the initial sampling frame. A random selection procedure was employed to identify one school from each administrative district, yielding five schools for inclusion. At the school level, all eligible female students present during the data collection period were invited to participate, thereby applying a complete record strategy among eligible students within each institution. Eligibility criteria for the participants were female students from the selected schools aged 14–20 years old. Adolescent girls who had not yet experienced menarche were excluded to reduce variability related to pubertal development. Schools were randomly selected using the research randomization tool. All selected schools agreed to participate in the study. In total, 512 female students were approached, of whom 482 completed the survey and were retained for analysis, corresponding to a response rate of 94.14%.

2.2 Procedure

This study obtained ethical approval from the Health Research Ethics Committee, University of Muhammadiyah Malang (No. E.5.a/181/KEPK-UMM/X/2019). After obtaining ethical approval, this study also obtained administrative permits from the local educational authority in Malang City, East Java, Indonesia. To meet ethical standards, the researcher distributed informed consent to the potential participants, and they were required to return a signed parental consent form before data collection. Only female students who voluntarily provided personal assent and had parental consent participated, resulting in a final 482 participants. Before data collection, the researcher provided clear explanations, including the study procedure, confidentiality of the data, and the outcome of this study. The data collection process took place in the school and required at least 20 min to complete. The data collection process was conducted between June and November 2019.

2.3 Measurements

2.3.1 Demographic Characteristics

The demographic data of the participants were self-reported, including age (years), height (cm), and weight (kg). Height and weight data were used to calculate the participants' BMI.

2.3.2 Depression

Depression was assessed using the 21-item Beck Depression Inventory-II (BDI-II). Participants were asked to rate depressive symptoms experienced over the past two weeks. Each item is scaled between 0 = "no" and 3 = "severe." The total score ranged from 0 to 63. Higher scores indicate more depressive symptoms. The BDI-II has been adapted to the Indonesian population [21]. In the present study, the BDI-II had good internal consistency (α = 0.86).

2.3.3 Perceived Stress

Individual stress levels were assessed using the 10-item Perceived Stress Scale (PSS) [22]. Each item is ranked from 0 = "never" to 4 = "very often." The total score was calculated by summing all items, ranging from 0 to 40, with higher scores indicating greater perceived stress. This questionnaire has been widely used in Indonesia [23,24]. Cronbach's alpha for this study was 0.73.

2.3.4 Sedentary Lifestyle

Sedentary behavior was measured using the adolescent sedentary activity questionnaire (ASAQ) [25,26], which has been adapted to the Indonesian population [27]. Participants were asked to report the amount of time spent in various sedentary activities during a week, including watching television, playing video games, using computers or smartphones, and other sitting-based leisure activities. To facilitate accurate recall, each participant was informed that there were 168 h in a week, of which roughly 40 h were spent in school and roughly 56 h were spent sleeping (assuming eight hours of sleep a day). According to these estimates, the maximum amount of leisure time available per week is around 72 h, which may plausibly be dedicated to sedentary activities. The sedentary time was calculated by summing the duration of all sedentary activities within a week, divided by seven.

2.4 Statistical Analysis

All statistical analyses were performed using SPSS 29 (IBM Corp., Armonk, NY, USA). Descriptive analysis used mean and standard deviation for continuous variables. The Kolmogorov-Smirnov test was used to check the normality of the data distribution. In the bivariate analysis, Spearman's correlation was employed because the data were not normally distributed. Multiple mediation analysis was performed using Hayes PROCESS Model 4 to examine indirect associations between variables. In this model, sedentary behavior served as the independent variable and depression as the dependent variable, with BMI and perceived stress as mediators. Age was included as a control variable. Pairwise deletion was applied due to minimal missing data. The analysis employed bootstrapping with 5000 samples, a 95% confidence interval (CI), and a significance level of $p < 0.05$.

3 Results

A total of 482 adolescent girls participated in this study, with a mean age of 16.24 years (SD = 1.12). The mean BMI was 20.62 (SD = 3.44). The mean score of depression was 10.44 (SD = 7.15), and the mean score for perceived stress was 20.24 (SD = 5.19). The average hours of sedentary behavior were 9.38 (SD = 6.06) hours per day. Detailed participant characteristics are presented in Table 1.

Table 1: Characteristics of the participants.

Characteristic	Mean (SD)	Median (IQR)
Age, years	16.24 (1.12)	16.00 (2.00)
BMI, kg/m^2	20.62 (3.44)	20.00 (4.12)
Depression	10.44 (7.15)	9.00 (9.25)
Perceived stress	20.24 (5.19)	21.00 (7.00)
Sedentary lifestyle, hours	9.38 (6.06)	8.14 (9.26)

Note: BMI, Body Mass Index; SD, Standard deviations; IQR, Interquartile Range.

Table 2 presents the bivariate correlation results between the variables. Depression was positively correlated with BMI (r = 0.103, p < 0.05), perceived stress (r = 0.416, p < 0.001), and age (r = 0.169, p < 0.001). Sedentary behavior was negatively correlated with age (r = −0.146, p < 0.01). BMI showed a positive correlation with age (r = 0.102, p < 0.05). Perceived stress was positively correlated with age (r = 0.221, p < 0.001).

Table 2: Correlation analysis between variables.

Variable	1	2	3	4	5
1. Depression	1				
2. Sedentary lifestyle	0.011	1			
3. BMI	0.103*	−0.027	1		
4. Perceived Stress	0.416***	0.036	−0.002	1	
5. Age	0.169***	−0.146**	0.102*	0.221***	1

Note: *p < 0.05, **p < 0.01, ***p < 0.001. BMI, Body Mass Index.

Fig. 1 illustrates the direct effects of sedentary behavior, BMI, perceived stress, and depression. The direct effect of sedentary behavior showed a positive association with perceived stress (β = 0.133, p = 0.010, f^2 = 0.051), which indicates that higher sedentary behavior is associated with a higher level of perceived stress. According to Cohen's benchmarks [20], this represents a small effect size, suggesting that sedentary behavior contributes modestly but significantly to perceived stress among adolescent girls.

BMI was associated with depression (β = 0.133, p = 0.005, f^2 = 0.031), representing a small effect size, indicating that higher BMI is associated with higher depression levels. Perceived stress showed a strong positive association with depression (β = 0.392, p < 0.001, f^2 = 0.209), which corresponds to a moderate effect size, indicating that perceived stress plays a substantial role in explaining depressive symptoms among adolescent girls.

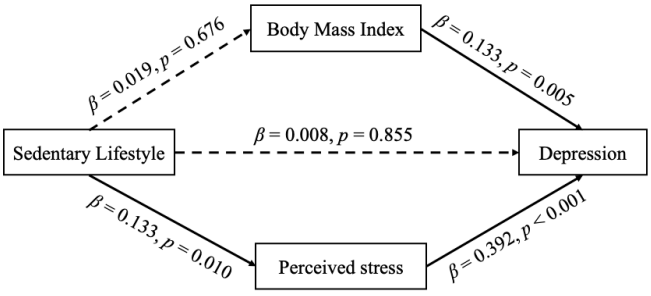

Figure 1: Path diagram of direct association between variables. Note: The dashed lines indicate non-significant effects.

Although sedentary behavior was not directly correlated with depressive symptoms, mediation analysis was conducted to explore whether indirect pathways through perceived stress or BMI were present, as shown in Table 3. The results revealed a significant mediation effect of perceived stress on the relationship between sedentary behavior and depression (β = 0.052, t = 2.410, 95% CI: 0.014, 0.100). However, BMI had no mediation effect on the association between sedentary behavior and depression. The total indirect effect was significant; however, only perceived stress contributed significantly to this indirect association, whereas BMI did not.

Table 3: Indirect effects of the mediators on the relationship between sedentary lifestyle and depression.

Path	β	SE	t	95% CI		p
				Lower Limit	Upper Limit	
Total indirect effect	0.055	0.022	2.506	0.016	0.102	0.012
Indirect effect						
Sedentary lifestyle → BMI → depression	0.003	0.007	0.384	−0.009	0.019	0.701
Sedentary lifestyle → Perceived stress → Depression	0.052	0.022	2.410	0.014	0.100	0.016

Note: BMI, Body Mass Index; SE, Standard error; CI, Confidence interval.

4 Discussion

This study has examined the relationship between sedentary behavior, perceived stress, BMI, and depression among adolescent girls in public senior high schools. Results of our study showed that sedentary behavior is significantly associated with perceived stress. Perceived stress and BMI have a direct positive association with depression. Perceived stress showed as the primary mediator linking sedentary behavior and depression, whereas BMI showed a direct association with depression but did not function as a mediator.

The findings indicate that higher perceived stress levels are associated with greater depressive symptoms. Consistent with prior research, perceived stress demonstrated a strong and positive association with depressive symptoms [28]. The psychological mechanism identified that stress in adolescent girls intensifies depressive symptoms, which are influenced by individual disposition and coping resources [28]. Perceived stress in women is closely related to the severity of depressive symptoms because levels of perceived stress not only trigger but also maintain psychological distress [29,30]. The interaction between stress and lack of positive resources worsens depressive symptoms [30]. Adolescence is a critical period of brain development that requires adequate psychosocial resources to support emotional regulation and mental health avoid the development of depressive symptoms [31]. Moreover, perceived stress is also known to increase the level of depression through the mechanism of imbalanced levels of neuroticism [32]. In conclusion, stress plays a crucial role as a psychosocial factor in depression.

Our study found that higher sedentary behavior was associated with higher perceived stress levels, which in turn, perceived stress mediates the relationship between sedentary behavior and depression. High levels of leisure screen time and decreased physical activity may contribute to anxiety, low self-esteem, suicidal thoughts, loneliness, depression, and psychological distress [33]. Lubans et al. [34] argued that physical activity might influence the individual's neurobiological aspects, which interfere with cognitive function in mental processes. Within this framework, adolescent girls with higher sedentary behavior may experience elevated depressive symptoms through increased perceived stress.

The present study indicates that sedentary behavior was not directly associated with depression but was indirectly mediated through perceived stress. Adolescent girls who engage in highly sedentary behavior may have higher depression due to the mediating role of perceived stress. Increased sedentary behavior

may elevate perceived stress, potentially through reduced physical activity and diminished opportunities for mood regulation [7,35]. This heightened stress further exacerbates depressive symptoms, positioning stress as a key intermediary factor [7,35].

Although sedentary behavior is often conceptualized as a risk factor for depressive symptoms [2,7], the cross-sectional design precludes conclusions about temporal directionality. It is also plausible that adolescents experiencing depressive symptoms may engage in greater sedentary behavior, such as excessive social media use, gaming, or watching television [36]. Therefore, the relationship between sedentary behavior and depression may be bidirectional, and the observed associations should be interpreted as correlational rather than causal.

BMI was directly associated with high depression levels but did not mediate the association between sedentary behavior and depression. The absence of a mediating effect indicates that sedentary behavior may not influence depression primarily through weight-related mechanisms in this population. BMI may reflect physical health status but may not adequately explain psychological mechanisms related to depressive symptoms in adolescent girls [37]. Body image and dissatisfaction are more likely to increase psychological distress than BMI [37]. Therefore, subjective perceptions might hold greater importance than objective measures such as BMI when it comes to depression. In addition, BMI can also be influenced by multiple factors beyond sedentary behavior, including daily intake, genetics, and pubertal development, which were not assessed in this study [38].

In our study, age as a control variable was correlated with sedentary behavior, depression, stress, and BMI. Sedentary behavior in adolescent girls tends to decrease with age, possibly due to the increased participation in physical interaction with their peers, and influences their body image and social expectations [39,40]. Age can influence depression in adolescent girls due to cumulative physiological and psychosocial changes that elevate vulnerability. Age is positively correlated with depression owing to cumulative biopsychosocial stressors and metabolic changes [41]. Older adolescents may experience higher depressive symptoms due to cumulative academic, social, and psychosocial stressors, which may be linked to psychosocial stress, increased BMI, and metabolic dysregulation [41,42]. A study found significant links between anxiety, depression, overweight status, and psychosocial stress in older age groups [43]. These multifactorial pathways clarify the complexity of depression in adolescent girls.

Although some observed effect sizes were small, these findings remain meaningful in the context of adolescent mental health research. In behavioral and public health studies, even small effect sizes may have important implications at the population level, particularly when risk factors such as sedentary behavior are highly prevalent among adolescents. The present findings suggest that sedentary behavior may indirectly influence depressive symptoms through increased perceived stress. From a public health perspective, reducing sedentary behavior and implementing stress-management interventions in school settings may help mitigate depression risk among adolescent girls.

In general, psychological factors, such as perceived stress, are associated with worse mental health, especially depression. This is directly linked to the SDG 3 indicator for better mental health and well-being across all age groups. These results have significant implications for public health, informing the design of interventions to reduce depressive symptoms in adolescents. The practical implication of these findings is that interventions targeting adolescent mental health should not only focus on physical activity promotion but also address psychological stress. School-based programs that encourage reduced screen time, active lifestyles, and stress management strategies may contribute to improving psychological well-being among adolescent girls. Given the high prevalence of sedentary lifestyles among modern adolescents, even modest effects may translate into meaningful mental health benefits at the population level. Such

interventions should not only minimize sedentary behavior but also emphasize stress management strategies. School-based and community interventions that include stress reduction, adaptive coping skills, and balanced screen time may be more effective than those that focus only on sedentary behavior. Integrating mental health awareness and stress management into physical activity promotion programs might improve their efficacy in improving adolescent mental health.

5 Limitations

Although sedentary behavior, perceived stress, BMI, and depression were found to be significantly correlated, this study had several limitations. First, a cross-sectional design cannot determine causal associations between variables. For instance, while sedentary behavior may elevate stress, it could also serve as a coping mechanism for increased stress or depression. Furthermore, longitudinal studies are necessary to clarify the time order and disentangle potential relationships between sedentary behavior, perceived stress, and depressive symptoms. Second, the results might not generalize to all adolescents because the participants are limited to girls from senior high schools in Malang City, Indonesia. Third, using self-reported questionnaires with differences in recall time frames across the measurements, such as the Adolescent Sedentary Activity Questionnaire (ASAQ) was assessed based on a typical week, and the Beck Depression Inventory-II (BDI-II) was assessed over the past two weeks, and PSS-10, which reflected recent stress experiences, may lead to recall and social desirability bias. Although these measures reflect similar and closely related experiences, the different time frames can make it harder to understand the mediation analysis. Therefore, the mediation findings should be interpreted as statistical associations rather than evidence of causality. Fourth, focusing exclusively on adolescent girls limits relevance to male adolescents who might experience different interactions between sedentary behavior and mental health. Finally, although BMI was examined as a potential mediator, it did not mediate the relationship between sedentary behavior and depression, and it is a fundamental measure that does not account for the particulars of body composition. According to our findings, further studies might consider other subjective measures, like body dissatisfaction or body image perception, that are more relevant for understanding the psychological distress.

6 Conclusions

This study demonstrates that perceived stress functions as a mediator in the relationship between sedentary behavior and depressive symptoms in adolescent girls, although BMI does not. These results indicate the importance of addressing psychological stress to alleviate the mental health issues associated with sedentary behavior in adolescent girls. Our results highlight the importance of public health actions focused on enhancing stress management and reducing sedentary behavior, in alignment with SDG 3, which supports mental health. Future strategies should incorporate physical activity with psychological resilience and pursue further investigations into various mediators, including body image satisfaction.

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Availability of Data and Materials: Restrictions apply to the availability of these data due to ethical reasons. Data may be available from the corresponding author upon reasonable request.

Ethics Approval: This study obtained ethical approval from the Health Research Ethics Committee, University of Muhammadiyah Malang (No. E.5.a/181/KEPK-UMM/X/2019). This study also obtained administrative permits from the local educational authority in Malang City, East Java, Indonesia. Informed consent was obtained from parents and all participants.

Conflicts of Interest: The authors declare no conflicts of interest.

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