



# Determinants Of Metabolic Risk In Adolescents: Stress, Dietary Pattern, And Physical Activity

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## ABSTRACT

**Introduction:** The risk of metabolic disease among adolescents has become a public concern, influenced by various behavioral and psychological factors. **Objective:** This study aims to identify the determinants of metabolic risk among adolescents, focusing on stress, dietary pattern, and physical activity. **Methods:** A cross-sectional study was conducted on 60 adolescents in one of the high schools in Sidoarjo. Data were collected using a questionnaire and analyzed using the chi-square test and multivariable logistic regression. **Results:** The results showed that several factors were significantly associated with metabolic risk in the bivariate analysis, namely stress level, diet, physical activity, lifestyle and gender ( $p < 0.05$ ). However, in the multivariable model, only stress and physical activity remained significant predictors. Adolescents with low physical activity had a significantly higher risk of developing metabolic disease ( $p = 0.005$ ), while higher stress levels were also associated with an increased risk of developing metabolic disease ( $p = 0.007$ ). Dietary patterns were not significantly associated after adjustment ( $p > 0.05$ ). **Conclusion:** Stress and physical activity are key determinants of metabolic risk among adolescents.

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## INTRODUCTION

Metabolic disorders among adolescents have emerged as a significant global public health problem, driven by the increasing prevalence of metabolic risk factors such as obesity, insulin resistance, and dyslipidemia (Chong et al., 2023). Adolescence is a critical developmental period during which health-related behaviors, including dietary habits and physical activity patterns, are formed and tend to persist into adulthood (Carducci et al., 2025). Several changes occur during adolescence, including physical changes, brain development, sexual organ maturation, and psychosocial development, which influence health-related behaviors (Widjaja et al., 2020). The rapid transition to a modern lifestyle characterized by reduced physical activity, increased sedentary behavior, and poor dietary quality is accelerating this trend.

Based on the results of the latest systematic review, the prevalence of metabolic syndrome in adolescents with obesity was 29.4%, with prevalence ranging from 2.1% to 74.4% in various studies (Wentzel et al., 2025). The prevalence of metabolic syndrome in adolescents and young adults in Indonesia reaches 13.36%. High-risk eating behaviors and obesity are significantly associated factors, with a nearly 10-fold and more than 15-fold increased risk, respectively (Ningsih et al., 2026). A similar phenomenon was also identified among adolescents in Sidoarjo, where many students exhibited low levels of physical activity, prolonged screen time, irregular sleep patterns, frequent consumption of fast food and sugary drinks, and limited participation in regular exercise. Initial observations at the study site also indicated that adolescents tended to spend more time using smartphones and engaging in sedentary activities after school hours than participating in outdoor activities or physical activity. These conditions may increase the risk of developing metabolic disorders at an early age and highlight the importance of conducting this study among adolescents in Sidoarjo.

The consequences of metabolic risk during adolescence are considerable, as they are strongly associated with long-term health outcomes, including cardiovascular diseases and type 2 diabetes mellitus in adulthood (Supreya Swarup et al., 2024). In addition to biological and behavioral factors, psychological factors such as

stress play an important role in metabolic regulation through neuroendocrine pathways, particularly activation of the hypothalamic-pituitary-adrenal (HPA) axis, which may contribute to insulin resistance and obesity (Kivimäki et al., 2023; Merabet et al., 2022). These findings emphasize that metabolic risk is multifactorial, involving complex interactions between psychological, behavioral, and environmental factors.

Although evidence on individual risk factors such as diet, physical activity, and stress is increasing, integrated evidence examining the combined effects of these factors on metabolic risk in adolescents is limited. Furthermore, the relative contribution of family environment compared to peer influence and lifestyle behaviors remains inconsistent across studies, particularly in different sociocultural contexts. Therefore, this study aimed to analyze the associations between gender, stress levels, diet, lifestyle, physical activity, and family environment with metabolic disease risk in adolescents, and to identify the most influential factors that can be targeted for preventive interventions.

**METHOD**

This is a descriptive analytical study using a cross-sectional approach. This approach was used to obtain a comprehensive picture of the relationship between psychological, behavioral, and environmental factors and metabolic risk in adolescents. This study was conducted at a high school in Sidoarjo City, East Java, in January 2026. The study population consisted of all grade XII students attending the school, with total population of 63 students. The sampling technique used was total sampling, meaning all adolescents who met the inclusion criteria at the time of the study were included as respondents. The sample size for this study was 60 respondents. The inclusion criteria in this study were: (1) students enrolled in grade XII at the selected high school, (2) aged 17-19 years, (3) willing to participate in the research by providing informed consent, (4) able to read and understand the questionnaire, and (5) present during the data collection process.

Data were collected using a self-developed questionnaire that included data on respondent characteristics, diet, lifestyle, physical activity, family environment, and risk of metabolic disease. Stress levels were measured using a questionnaire using the Perceived Stress Scale-10 (PSS-10) (Hakim et al., 2024). This tool has been proven valid and reliable in various studies. The PSS consists of three versions: PSS-14, PSS-10, and PSS-4. The most frequently used version is the PSS-10, due to its efficiency while remaining valid and reliable. Data were analyzed using univariate analysis, bivariate analysis using the chi-square test, and multivariate analysis using logistic regression. In the multivariate analysis, only the variables with the strongest influence and strong theoretical relevance, namely stress level, diet, and physical activity, were entered into the logistic regression model. This study used an anonymous questionnaire survey involving adolescents with minimal risk and no invasive procedures. Permission to conduct the study was obtained from the school administration. Participation was voluntary, and all respondents provide informed consent before completing the questionnaire. Participant anonymity and confidentiality were ensured throughout the study process.

**RESULT**

**Table 1. Respondent Characteristic (n=60)**

Variable	n	%
<b>Age</b>		
17 years old	27	45,0%
18 years old	28	46,7%
19 years old	5	8,3%
<b>Gender</b>		
Male	15	25,0%
Female	45	75,0%
<b>Stres Level</b>		
Low	14	23,3%
Moderate-severe	46	76,7%
<b>Dietary Pattern</b>		
Healthy	14	23,3%
Unhealthy	46	76,7%
<b>Lifestyle</b>		
Healthy	6	10%
Risky	54	90%
<b>Physical Activity</b>		
Active	8	13,3%
Inactive	52	86,7%

Variable	n	%
<b>Family environment</b>		
Supportive	44	73,3%
Not Supportive	16	26,7%
<b>Metabolic Disease Risk</b>		
Not at Risk	16	26,7%
At Risk	44	73,3%

Source: Primary data (2026)

Based on respondent characteristics data, the majority of respondents were 18 years old (46.7%), followed by 17 years old (45,0%) and 19 years old (8.0%). The majority of respondents were female (75.0%). The distribution of characteristics showed that most respondents were in the moderate-severe stress category (76.7%) and had unhealthy dietary patterns (76.7%). In addition, the majority of respondents had a risky lifestyle (90.0%) and were physically inactive (86.7%). Most respondents came from a supportive family environment (73.3%). However, the majority of respondents were at risk of developing metabolic diseases (73.3%) (Table 1).

**Table 2. Bivariate Analysis Results of the Relationship between Risk Factors and the Risk of Metabolic Diseases in Adolescents (n=60)**

Variabel	No Metabolic Disease Risk n (%)	Metabolic Disease Risk n (%)	Total n (%)	p-value
<b>Gender</b>				
Male	1 (6,7%)	14 (93,3%)	15 (100%)	0.023
Female	17 (37,8%)	28 (62,2%)	45 (100%)	
<b>Stres Level</b>				
Low	9 (64,3%)	5 (35,7%)	14 (100%)	< 0.001*
Moderate-severe	7 (15,2%)	39 (84,8%)	46 (100%)	
<b>Dietary Pattern</b>				
Healthy	9 (64,3%)	5 (35,7%)	14 (100%)	0.001*
Unhealthy	9 (19,6%)	37 (80,4%)	46 (100%)	
<b>Lifestyle</b>				
Healthy	5 (83,3%)	1 (16,7%)	6 (100%)	0.004*
Risky	11 (20,4%)	43 (79,6%)	54 (100%)	
<b>Physical Activity</b>				
Active	7 (87,5%)	1 (12,5%)	8 (100%)	< 0.001*
Inactive	11 (21,2*)	41 (78,8%)	52 (100%)	
<b>Family environment</b>				
Supportive	13 (29,5%)	31 (70,5%)	44 (100%)	0.899
Not Supportive	5 (31,3%)	11 (68,8%)	16 (100%)	

Source: Primary data (2026)

Based on Table 2, the results of the bivariate analysis indicate a significant association between several factors and the risk of metabolic disease in adolescents. Gender was significantly associated with metabolic risk ( $p = 0.023$ ), with a higher risk proportion in males (93.3%) than in females (62.2%). Stress levels also showed a highly significant association ( $p < 0.001$ ), with respondents with moderate to severe stress having a higher proportion of metabolic risk (84.8%) compared to those with mild stress (35.7%). Similarly, dietary patterns were significantly associated with metabolic risk ( $p = 0.001$ ), with respondents with unhealthy dietary patterns having a higher risk (80.4%) than those with healthy dietary patterns (35.7%). Furthermore, a risky lifestyle was significantly associated with increased metabolic risk ( $p = 0.004$ ), with a 79.6% higher proportion than a healthy lifestyle (16.7%). Physical activity also showed a highly significant association ( $p < 0.001$ ), with less active respondents having a higher risk (78.8%) than active respondents (12.5%). Meanwhile, family environment did not show a significant association with metabolic disease risk ( $p = 0.899$ ).

In the bivariate analysis, several variables showed a significant association with metabolic risk, namely stress level, physical activity, diet, lifestyle, and gender. However, not all of these variables were included in the multivariate analysis. The selection of variables in the multivariate model was based on theoretical relevance and the research objectives, which focused on modifiable risk factors. In this case, physical activity, diet, and stress levels were chosen because they are behavioral and psychological factors that can be intervened.

Meanwhile, gender is a non-modifiable demographic factor and therefore does not receive priority in predictive models aimed at identifying controllable risk factors. Therefore, gender was not included in the logistic regression analysis, although it is still reported in the bivariate analysis as a respondent characteristic variable.

**Table 3. Results of Logistic Regression Analysis of Risk Factors for Metabolic Diseases in Adolescents**

Variable	B	SE	OR (Exp B)	95% CI	p-value
Stress Level	-2.683	0.993	0.068	0.010 – 0.479	0.007*
Physical Activity	-3.536	1.252	0.029	0.003 – 0.339	0.005*
Dietary Pattern	-0.840	1.018	0.432	0.059 – 3.174	0.409

Source: Pimary data (2026)

Based on Table 3, the results of the logistic regression analysis indicate that physical activity and stress levels are significantly associated with the risk of metabolic disease in adolescents. Physical activity had a p-value of 0.005 (OR = 0.029; 95% CI = 0.003–0.339), indicating that respondents with lower physical activity had a higher metabolic risk compared to those who were more active. Stress levels were also significantly associated ( $p = 0.007$ ; OR = 0.068; 95% CI = 0.010–0.479), with respondents with moderate to severe stress levels having a higher risk of metabolic disease compared to those with mild stress. Meanwhile, diet did not show a significant association in the multivariate analysis ( $p = 0.409$ ; OR = 0.432; 95% CI = 0.059–3.174), indicating that after controlling for other variables, diet did not independently influence metabolic risk. Based on these results, physical activity is the most dominant factor influencing the risk of metabolic disease in adolescents.

## DISCUSSION

### Metabolic Risk at Adolescent

In this study, the majority of respondents (73.3%) were at risk of developing metabolic disease. The risk of metabolic disease in adolescents is the result of a complex interaction between psychological, behavioral, and environmental factors. This condition is not influenced by a single factor, but rather by the accumulation of various interrelated determinants, such as diet, physical activity, emotional state, and environmental exposure that supports unhealthy behaviors (obesogenic environments). Modern lifestyle changes, including increased consumption of high-calorie foods and low physical activity, significantly contribute to increased metabolic risk in adolescents (Sahoo et al., 2015). In addition, psychological factors such as stress and emotional regulation can also influence health behaviors, which ultimately impact an individual's metabolic state. Zhang et al., (2025) emphasized that the development of metabolic risk in children and adolescents occurs through a dynamic interaction between biological, behavioral, and social environmental factors. Therefore, metabolic risks in adolescents cannot be understood in part, but must be seen as a result of the interrelationship of various factors that influence each other in the daily lives of adolescents.

### Gender and Metabolic Risk

The results of this study found that gender was significantly associated with the risk of metabolic disease in adolescents ( $p = 0.023$ ), with a higher proportion in males (93.3%) than females (62.2%). Gender differences are associated with variations in body fat distribution and metabolic profiles in adolescents, which may influence the risk of metabolic disease (Laxy et al., 2018). Other research results also show that there are biological and hormonal factors that influence the differences in the risk of metabolic disease between men and women (Bellastella et al., 2019). Although the association between gender and metabolic disease risk was statistically significant, gender was not included in the multivariate analysis because it is a non-modifiable risk factor. Therefore, gender serves more as a baseline characteristic of respondents reflecting biological variation, rather than a modifiable risk factor through intervention. These results still serve as epidemiological information in describing groups of adolescents who are more vulnerable to metabolic risks.

### Stress Levels and Metabolic Risk

Stress levels were significantly associated with metabolic risk ( $p < 0.001$ ) and remained significantly associated in regression analysis ( $p = 0.007$ ), indicating that stress is an independent factor contributing to increased risk of metabolic disease in adolescents. Chronic stress activates the hypothalamic-pituitary-adrenal (HPA) axis, which increases cortisol secretion, which in turn contributes to insulin resistance and body fat accumulation (Janssen, 2022; Liyanarachchi et al., 2017). This condition shows that stress levels not only have a psychological impact, but also have a significant influence on the body's metabolism. In addition to physiological effects, stress also influences behavioral changes such as increased consumption of high-calorie

Dewanti, N., Septiansyah, D.A., Rohmawati, N.R., & Safitri, M.A. (2026). Determinants Of Metabolic... foods, overeating, and decreased physical activity, which indirectly increases the risk of metabolic disorders in adolescents.

### **Dietary Pattern and Metabolic Risk**

Dietary pattern significantly influenced the risk of metabolic disease in bivariate analysis ( $p = 0.001$ ), but not in multivariate analysis ( $p = 0.409$ ). This suggests that while diet plays a role in the risk of metabolic disease, its influence is not independent after controlling for other variables. Unhealthy diets, such as high consumption of sugar, fat, and ultra-processed foods, are known to contribute to metabolic disorders, including obesity, insulin resistance, and metabolic syndrome (Calcaterra et al., 2023; Kirti and Singh, 2023). However, the influence of diet on metabolic risk does not occur in isolation, but is strongly influenced by interactions with other lifestyle factors, particularly physical activity, daily habits, and overall lifestyle. The combination of these factors collectively determines a person's energy balance and metabolic status (Koliaki et al., 2018; WHO, 2020). Therefore, the insignificance of dietary patterns in the multivariate analysis suggests that its effect is likely mediated or influenced by other variables, so that its contribution is not dominant when analyzed simultaneously with other risk factors.

### **Physical Activity and Metabolic Risk**

Physical activity was significantly associated with metabolic risk ( $p < 0.001$ ) and was the most dominant factor in multivariate analysis ( $p = 0.005$ ; OR = 0.029). An odds ratio of less than 1 indicates that physical activity is protective against metabolic risk in adolescents, where increased physical activity reduces the likelihood of metabolic disorders. Physiologically, regular physical activity acts as a powerful non-pharmacological strategy to improve metabolic health by increasing insulin sensitivity, regulating glucose/lipid metabolism, and maintaining energy balance. This is achieved through acute effects mediated by muscle contractions and long-term adaptations (Koliaki et al., 2018; WHO, 2020). On the other hand, low physical activity or sedentary behavior can increase the risk of obesity, insulin resistance, and metabolic syndrome in adolescents (Aziz and Sentani, 2025; Goyal and Rakhra, 2024). This confirms that physical activity is a key protective factor in preventing metabolic risks in adolescents. Therefore, increasing physical activity needs to be a primary focus of intervention efforts, whether through active lifestyle education, increasing daily activity levels, or school-based programs that encourage adolescents to move more frequently.

### **Lifestyle and Metabolic Risk**

Lifestyle was significantly associated with metabolic risk in adolescents ( $p = 0.004$ ). This finding suggests that lifestyle patterns play a significant role in determining an individual's metabolic status. A risky lifestyle, characterized by low physical activity and high levels of sedentary behavior, is known to contribute to an increased risk of metabolic disorders such as obesity and metabolic syndrome (Park et al., 2020; Tri Tjahjono and Arthamin, 2024). A sedentary lifestyle and excessive calorie consumption create an energy imbalance, causing the body to store excess energy as fat. This process increases fat accumulation, particularly visceral fat, which is a major cause of metabolic syndrome by triggering insulin resistance, hypertension, and dyslipidemia (De Leon, 2019; Sepreeya Swarup et al., 2024). In this study, the high proportion of respondents with risky lifestyles indicates that behavioral factors play a significant role in determining adolescents' metabolic health status. This suggests that lifestyle changes are crucial in metabolic risk prevention efforts. Therefore, interventions focused on increasing physical activity, reducing sedentary behavior, and improving daily lifestyle habits are the most relevant strategies for reducing metabolic risk in adolescents.

### **Family Environment and Metabolic Risk**

Family environment was not significantly associated with metabolic risk ( $p = 0.899$ ). Research conducted by Havewala et al., (2021; Watts et al., (2024) showed that during adolescence, peer influence on individual behavior increases, while family influence tends to decrease relative to shaping health behavior. Furthermore, the dominance of external factors such as peers and the social environment may have statistically reduced the influence of the family in this study, as adolescent behavior is largely shaped through social interactions outside the home. Therefore, the insignificant relationship between the family environment and adolescent behavior in this study may be explained by the stronger dominance of external factors in shaping adolescent behavior. The more intense influence of peers and the social environment may have statistically reduced the family's contribution, although theoretically, the family remains an important factor in the development of adolescent health behavior.

## CONCLUSION

This study shows that the majority of adolescents are at risk of developing metabolic disease. Several factors, including gender, stress level, diet, lifestyle, and physical activity, were found to be associated with metabolic risk in bivariate analysis, while family environment showed no significant association. However, in multivariate analysis, only stress level and physical activity remained significant predictors, suggesting that these two factors play a more independent role in determining metabolic risk. Other variables, such as diet and gender, were not significant after adjustment, suggesting that their effects may be influenced by other interrelated factors.

Overall, metabolic risk in adolescents is shaped by a complex interaction between behavioral and psychological factors. Physical activity emerged as a key protective factor, while stress contributed to increased risk through physiological and behavioral mechanisms. These findings emphasize that prevention efforts should focus primarily on promoting regular physical activity and improving stress management among adolescents to reduce the risk of metabolic disease.

## RECOMMENDATION

Based on the findings of this study, several recommendations can be made. Adolescents are encouraged to increase regular physical activity and reduce sedentary behavior as primary strategies for preventing metabolic risk. Furthermore, stress management should be enhanced through healthy coping strategies such as relaxation techniques, time management, and engagement in positive social or recreational activities. Attention to overall lifestyle habits, including maintaining a balanced daily routine, is also important to support better metabolic health.

For schools and healthcare providers, prevention programs should focus on promoting active lifestyles and providing education on stress management as part of adolescent health promotion. School-based interventions, such as structured physical activity programs and mental health awareness sessions, may be effective in reducing metabolic risk. Furthermore, future research is recommended to explore additional psychosocial and environmental factors that may contribute to metabolic risk, using larger sample sizes and longitudinal designs to better understand causal relationships.

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