

Original Research Article

Relationship of Sweet Taste Threshold, Sugar Consumption, and Nutritional Status with Blood Glucose and Type 2 Diabetes in Adolescents

ABSTRACT

Diabetes mellitus is a non-communicable disease with a steadily increasing prevalence among adolescents. According to the *International Diabetes Federation* (2023), the prevalence of type 2 diabetes mellitus increases with age in children and adolescents. To analyze the relationship between sweetness threshold, sugar consumption patterns, and nutritional status with fasting blood glucose levels in high school adolescents in Turikale District, Maros Regency. This cross-sectional study involved 70 respondents selected using simple cluster random sampling. Sweetness threshold was measured using the three-alternative forced-choice (3-AFC) method, fasting blood glucose levels using a glucometer, and nutritional status based on IMT/U. There was no significant relationship between sweetness threshold ($p=0.134$), consumption of sweet foods and beverages ($p=0.867$), and nutritional status ($p=0.750$) with fasting blood glucose levels. Sweetness threshold, sugar consumption patterns, and nutritional status were not associated with fasting blood glucose levels in adolescents.

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INTRODUCTION

Non-communicable diseases (NCDs), also known as degenerative diseases, are a major public health issue due to their significant contribution to morbidity and mortality. NCDs are defined as a group of diseases that cannot be transmitted between humans and generally have a chronic course with gradual progression over a long period. ¹ According to the *World Health Organization* (WHO), NCDs will cause approximately 43 million deaths annually by 2025, equivalent to 75% of all global deaths. The majority of these deaths, approximately 73%, occur in low- and middle-income countries, including Indonesia.²

One of the most prevalent non-communicable diseases globally is diabetes mellitus. According to the *International Diabetes Federation* (IDF), the prevalence of diabetes mellitus among people aged 20–79 globally reached 11.1% in 2024, or approximately 588.7 million people. China ranked first with 148.0 million sufferers, followed by India with 89.8 million, the United States with 38.5 million, Pakistan with 34.5 million, and Indonesia with 20.4 million. Indonesia's position, ranked fifth out of the 10 countries with the

highest number of diabetes sufferers in the world, confirms that diabetes has become a very serious public health problem.³

Basic Health Research (Riskesdas) data indicate an increasing trend in the prevalence of diabetes mellitus in Indonesia over time. In 2007, the prevalence of diabetes mellitus was recorded at 1.1%, then increased to 1.5% in 2013, remained stagnant at 1.5% in 2018, and rose again to 1.7% in 2023. More concerning, this increase in prevalence is not limited to the general adult population but has also begun to shift toward and pose a threat to younger age groups.⁴⁻⁷ The shifting trend of diabetes mellitus among younger age groups, particularly those aged 15–24 years,ssssssssss has become a phenomenon that requires special attention.

The 2018 Basic Health Research (Riskesdas) data raised a warning by reporting cases of diabetes in this age group, with a prevalence based on physician diagnosis of 0.1%.⁶ Meanwhile, the 2023 Indonesian Health Survey (SKI) data indicate that the prevalence of impaired fasting blood glucose (FBG) among individuals aged 15–24 years has reached a relatively high level of 10.7%. Based on educational status, the prevalence of impaired FBG among adolescents who are still attending school was even higher, reaching 11.0%, or approximately 1,282 adolescents.⁷ These findings demonstrate that type 2 diabetes mellitus (T2DM) has now emerged as a significant global health problem that clearly affects the adolescent population.⁸

The threat of a diabetes mellitus epidemic is also reflected at both the regional and local levels. According to the results of the 2023 Indonesian Health Survey (SKI), the prevalence of diabetes mellitus based on physician diagnosis among the population aged ≥ 15 years in South Sulawesi Province increased from 1.8% in 2018 to 2.0% in 2023. Meanwhile, based on physician diagnosis across all age groups, South Sulawesi Province ranked 18th among the 38 provinces in Indonesia, with a prevalence of 1.5%.⁷ This situation is further supported by data from the Maros District Health Office in 2025, which showed that the number of people with diabetes mellitus among those aged ≥ 15 years reached 3,054 individuals. Among all subdistricts in Maros District, Turikale Subdistrict accounted for 452 cases, or approximately 14.8% of the total diabetes mellitus cases, indicating that the area has a relatively high disease burden.⁹

Considering that adolescence is a period of rapid physical growth and development with high nutritional needs,⁸ lifestyle changes during this phase significantly determine their health risks. Adolescents are currently the age group with a very high consumption of sweet foods and drinks compared to other age groups. 2018 Riskesdas data confirms that the habit of consuming sweetened drinks >1 time per day in Indonesia reached 61.27%. In the group of adolescents aged 15–19 years, the proportion of sweetened drink consumption was recorded at 56.43%, which is in line with the figure in South Sulawesi of 56.29%. In addition, consumption of sweet foods >1 time per day is also relatively high, at 40.1% both nationally, in the group of adolescents aged 15–19 years, and in South Sulawesi.⁶

High exposure to sweet foods and drinks is directly correlated with variations in the sweetness threshold and the risk of metabolic disorders in adolescents. Excessive sugar consumption through sugar-sweetened beverages or soft drinks has been shown to increase the risk of overnutrition, obesity, and an increased waist-to-hip ratio (WHR).¹⁰⁻¹¹ Furthermore, overnutrition, such as overweight and obesity, can trigger insulin resistance in the body. As a result, there is a decrease in the ability of cells to absorb glucose, which directly impacts an individual's fasting blood glucose (FBS) levels.¹²

Based on the urgency of the problem, namely the high incidence of pre-diabetes (disturbed GDP) in the school-age group, the high pattern of sweet consumption in adolescents in South Sulawesi, and the large burden of diabetes cases in Turikale District, an in-depth analysis of the triggering factors is needed from an early age. Therefore, researchers feel the need to conduct a study that aims to determine "The Relationship Between Sweet Taste Threshold, Sugar Consumption Patterns and Nutritional Status Against Fasting Blood Glucose with the Risk of Type 2 Diabetes Mellitus in High School Adolescents in Turikale District, Maros Regency".

METHODS

This study employed an analytical survey with a cross-sectional design. The study sample consisted of high school students in Turikale District, Maros Regency, aged 15–18 years. The study sample consisted of high school students aged 15–18 in Turikale District, Maros Regency. Participants were required to fast for at least eight hours prior to data collection. A total of 70 students were included in the research. The sample schools in this study were selected using a multistage cluster random sampling technique. In the first stage, all schools in Turikale District ($n=16$) were grouped based on their geographic location into the central region (10 schools) and the peripheral region (6 schools). The number of sample schools in each region was then determined proportionally, with a target of six schools, resulting in four schools from the central region and two schools from the peripheral region. Next, a selection process was conducted based on the number of students meeting the minimum requirement for respondents. The selection results indicated that one school did not meet the required number of respondents, so the study was ultimately conducted in five schools.¹³

The sample size was determined using the Lemeshow formula to obtain the minimum number of respondents. Furthermore, the selection of students as respondents was carried out using a simple random sampling technique, ensuring that every student who met the inclusion criteria had an equal opportunity to be selected as a sample.¹⁴ This study was conducted in five high schools in Turikale District, Maros Regency, for a one-month period from March to April 2026. The dependent variable was fasting blood glucose (FBG) levels, while the independent variables were sweetness threshold, sugar consumption patterns, and nutritional status. Data collected included participant characteristics such as gender, age, father's occupation, and mother's occupation. The study began with anthropometric measurements to obtain data on the respondents' nutritional status. Nutritional status data were collected through weight measurements using a digital scale and height measurements using a stadiometer. Respondents were then categorized by BMI/A as undernutrition status (<-3 SD and $> +2$ SD), good nutrition status (-2 SD to $+1$ SD), overnutrition status ($+1$ SD to $+2$ SD), and obesity nutritional status ($> +2$ SD).¹⁵ Following anthropometric assessment, dietary intake data were collected through interviews using a 24-hour dietary recall method. The 24-hour dietary recall was used to describe respondents' actual intake, particularly carbohydrate intake, based on food and beverages consumed on two non-consecutive days. Repeated recalls were conducted to account for daily consumption variations on weekdays and weekends. Data were obtained through interviews using a household measuring instrument (URT), then converted to grams and analyzed using the Indonesian Food Composition Table (TKPI) or nutritional analysis software.¹⁶⁻¹⁷

Meanwhile, the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) was used to determine the frequency and consumption habits of respondents' sweetened foods and beverages. This instrument also provides information on portion sizes, thus estimating respondents' daily sugar intake.¹⁸ Prior to fasting blood glucose measurements, respondents were instructed to fast overnight for at least 8 hours. Fasting blood glucose (FBG) levels were measured using a glucometer with a strip-test method, which is considered easy to use, safe, and minimally invasive for adolescents. Blood samples were obtained through capillary fingertip sampling.¹⁹

The FBG results were displayed on the glucometer monitor and categorized as normal if the FBG level was < 100 mg/dL and prediabetes if the FBG level was ≥ 100 mg/dL.²⁰ During this period, respondents were instructed not to consume any food or beverages except plain water. Sweet taste threshold was assessed using the three-alternative forced-choice (3-AFC) method. In this study, five sets of samples were prepared with sucrose concentrations of 0,5 g/mL, 1 g/mL, 2 g/mL, 4 g/mL, and 8 g/mL, each dissolved in 100 mL of water. The sweet taste threshold test was conducted with the assistance of the researcher using a 1-mL syringe to collect the solution samples. The samples were then administered to the respondents using a small spoon. Testing began with the lowest concentration solution and was gradually increased to higher concentrations if the respondents were unable to detect sweetness. Respondents were given several minutes to identify each set of samples. Between each solution test, respondents were required to rinse their mouths with plain water to neutralize their taste perception.²¹⁻²²

The statistical analysis used in this study, namely, univariate analysis is used to describe the frequency distribution of respondent characteristics and main variables such as sweet taste threshold, sugar consumption patterns, nutritional status, and fasting blood glucose.²³ Data were processed and analyzed quantitatively using SPSS version 26.0 software. Chi-Square test to test the relationship between nominal or categorical variables.²⁴ The Spearman Rank Correlation Test to identify the direction and strength of the relationship in ordinal scale variables.²⁵ The analyzed data are presented in the form

of frequency distribution tables. This study was conducted in accordance with all applicable ethical requirements. Ethical clearance was granted by the Ethics Committee of the Muslim University of Indonesia, with ethical approval number 309/A.A/KEP-UMI/III/2026.

RESULT AND DISCUSSION

The study participants were senior high school students in Turikale District, Maros Regency. The demographic and health-related characteristics assessed Included sex, age, father's occupation, and mother's occupation. A summary of the respondents' characteristics is presented in the following table.

Table 1. Distribution of Respondents Characteristics

Respondents Characteristics	n	%
Sex		
Male	14	20,0
Female	56	80,0
Total	70	100
Age		
15 -16 years	44	62,9
17- 18 years	26	37,1
Total	70	100
father's occupation		
Unemployed	3	4,3
Civil servant, Police Officer, Military Personnel, State-Owned Enterprise (SOE) Employee	15	21,4
Self-employed	29	41,4
Farmer, Fisherman	11	15,7
Entrepreneur, Trader	6	8,6
Teacher	3	4,3
Others	3	4,3
Total	70	100

source: Primary data, 2026

Based on Table 1, the majority of respondents were aged 15–16 years, namely 44 people (62.9%), while respondents aged 17-18 years were 26 people (37.1%). Based on gender, the majority of respondents were female, namely 56 people (80.0%), while 14 people were male (20.0%). This age and gender distribution provides an overview of the characteristics of the adolescent population that was the subject of the study.

Parental occupation was included as an indicator of socioeconomic conditions that can influence children's access to and food consumption patterns. Parental occupational characteristics are related to the availability of time for caregiving and food supervision at home, while family economic conditions can influence children's purchasing power and access to food and beverages consumed outside the home .²⁶ This variable was used to describe the respondents' socioeconomic characteristics and was taken into consideration in interpreting their consumption patterns and sugar intake. However, father's occupation was not included as a primary analytical variable and its relationship to fasting blood glucose levels was not tested. Therefore, this variable is presented only to provide contextual information regarding the characteristics of the study population.

Table 2. Association Between Sweet Taste Threshold and Fasting Blood Glucose Levels Among Adolescents in Senior High Schools in Turikale District, Maros Regency

Sweet Taste Threshold	Fasting Blood Glucose	n (%)	p-value	Correlation Coefficient (r)
High	Pre-Diabetes	15 (21.4)	0.134	-0.405

p-value= Spearman's rank correlation test

source: Primary data, 2026

Analysis of the subgroup of adolescents with a high sweetness threshold and prediabetes status (n = 15) revealed no statistically significant relationship with fasting blood glucose levels (Spearman's $r = -$

0.405, $p = 0.134$). Although a moderate inverse trend was observed—suggesting that higher thresholds did not align with higher blood glucose in this specific subgroup—the lack of statistical significance indicates that sweetness sensitivity alone cannot reliably predict variations in adolescent blood glucose homeostasis. However, because the relationship was not statistically significant, this trend should be interpreted with caution and cannot be generalized to the wider adolescent population. Therefore, a higher sweetness threshold is not always associated with higher fasting blood glucose levels in adolescents with prediabetes status.

The findings of this study align with those of Rosalinda et al. (2024), who also reported no significant association between sweetness threshold and fasting blood glucose levels in adolescents ($p=0.210$). These results indicate that fasting blood glucose levels are influenced not only by sweetness sensitivity but also by various other factors that play a role in regulating glucose metabolism, such as hormonal, genetic, environmental, and daily food consumption patterns. Therefore, sweetness threshold is not the sole determinant that can explain variations in fasting blood glucose levels in adolescents.²¹

The lack of a significant relationship in this study may be explained by the complexity of the mechanisms regulating glucose homeostasis. Fasting blood glucose levels are largely influenced by various physiological factors, including insulin sensitivity, insulin secretion, glucagon regulation, and the ability of body tissues to utilize glucose. Furthermore, the age characteristics of the respondents may also influence the study results. During adolescence, organ and metabolic system function is generally still optimal, so the body's ability to maintain blood glucose balance is relatively better than in older age groups. This allows blood glucose levels to remain within the normal range despite variations in sensitivity to sweetness.²⁷

Furthermore, a high sweetness threshold does not always reflect actual high sugar consumption. Food and beverage consumption behavior in adolescents is a multifactorial phenomenon influenced by various factors beyond sensory aspects, such as the social and cultural environment, food availability, pocket money, individual preferences, and family eating habits. Although sensitivity to sweetness plays a role in shaping preferences for sweet foods and beverages, its effect on fasting blood glucose levels is indirect. In this study, respondents with a high sweetness threshold did have a potential tendency to accept or prefer sweeter foods. However, increases in fasting blood glucose levels are not solely determined by taste preferences, but are more influenced by total energy and sugar intake over the long term, physical activity, nutritional status, and the individual's metabolic capacity to regulate and utilize glucose. Therefore, the results of this study indicate that the relationship between sweetness threshold and fasting blood glucose levels in adolescents needs to be understood as a complex relationship influenced by various biological and behavioral factors and cannot be explained solely based on sweetness perception.²⁷

Table 3. Association Between Daily Consumption of Sweet Foods and Sugar-Sweetened Beverages and Fasting Blood Glucose Levels Among Adolescents in Senior High Schools in Turikale District, Maros Regency

Variables	Mean $\pm$ SD	<i>p</i> -value	Correlation Coefficient (<i>r</i>)
Intake of Sweet Drinks and Sweet Foods (g/day)	81.215 $\pm$ 65.736	0.867	0.020
Fasting Blood Glucose (mg/dL)	95.73 $\pm$ 10.881		

p-value= Spearman's rank correlation test

source: Primary data, 2026

The analysis of the relationship between sweet food and beverage intake and fasting blood glucose levels is presented in the table. Respondents had an average intake of sweet food and beverages of 81,215 $\pm$ 65,736 g/day, with an average fasting blood glucose level of 95,73 $\pm$ 10,881mg/dL. The results of the bivariate analysis showed no statistically significant relationship between the intake of sweet foods and drinks and fasting blood glucose levels (p -value=0,867). The correlation coefficient value ($r=0,020$) indicates that the strength of the relationship between the two variables is very weak and almost uncorrelated. Thus, variations in the amount of sweet food and drink intake are not in line with changes in fasting blood glucose levels in this study sample.

This finding aligns with research by Sitorus et al. (2020) on 140 students from the Faculty of Medicine, Sam Ratulangi University, who also reported no significant association between consumption of

sweet foods and drinks and blood sugar levels ($p = 0.116$). Although most respondents in the study frequently consumed sweet foods and drinks, their blood sugar levels remained within the normal range. This reinforces the indication that blood glucose levels are not solely determined by a single sweet intake but are influenced by a multifactorial mechanism.²⁸

One factor underlying this lack of association is the age characteristics of the study participants, who were in late adolescence. High school-aged adolescents generally have relatively dynamic levels of daily physical activity through academic and extracurricular activities. This vigorous physical activity increases the body's energy expenditure, allowing glucose from daily intake of sugary foods and drinks to be effectively metabolized for energy needs and not accumulate in the bloodstream.²⁹

Methodologically, these results are also influenced by the use of fasting blood glucose (FBG), which reflects the body's basal glucose homeostasis after an 8–10 hour fast. During this fasting phase, pancreatic beta cells in adolescents are generally still optimally functioning, producing insulin efficiently. This optimal mechanism prevents receptor impairment and cellular resistance, thereby effectively suppressing hepatic glucose production and maintaining blood glucose levels within the normal range during measurements.²⁹⁻³⁰

Table 4. Association Between Nutritional Status and Fasting Blood Glucose Levels Among Adolescents in Senior High Schools in Turikale District, Maros Regency

Nutritional status	Normal		Pre-Diabetes		Total		<i>p-value</i>
	n	%	n	%	n	%	
Normal nutritional status	31	44,3	27	38,6	58	82,9	0,750
Undernutrition	1	1,4	0	0,0	1	1,4	
Overweigh	2	2,9	1	1,4	3	4,3	
Obesity	5	7,1	3	4,3	8	11,4	
Total	39	55,7	31	44,3	70	100	

p-value= Chi-square test
source: Primary data, 2026

The distribution of respondent characteristics based on specific nutritional status categories and their relationship to fasting blood glucose status is presented in Table 4. Most respondents were in the normal weight group, either with normal blood glucose conditions (44.3%) or pre-diabetes (38.6%). In the group with higher anthropometric risk, respondents with obesity who had pre-diabetes were recorded at 4.3%, followed by the overweight group at 1.4%. The results of the bivariate chi-square test showed no statistically significant relationship between specific nutritional status categories and respondents' fasting blood glucose status ($p = 0.750$).

These findings are similar to previous research that reported no significant relationship between nutritional status and blood glucose levels in adolescents at the Resik Integrated Health Post (Posyandu) in Glidag Hamlet. However, these findings differ from several previous studies that generally showed a relationship between nutritional status and blood glucose levels, particularly in the context of undernutrition and obesity, as reported by Ardiani et al. (2021). These differences in findings emphasize that the clinical manifestations of anthropometric status and glucose levels are not always uniform across adolescent populations.³¹

The lack of a significant relationship in this study can be objectively explained by the multifactorial nature of blood glucose regulation. Variations in fasting blood glucose levels do not always correlate directly with external anthropometric status. Instead, post-fasting basal glucose homeostasis is more sensitive to daily lifestyle factors such as recent dietary habits, types of carbohydrates consumed, daily physical activity levels, and individual sleep patterns and stress management. In the late adolescent population in this study, the function of endogenous glucose metabolism regulation and insulin sensitivity are generally still physiologically efficient, so that fasting blood glucose levels can be maintained within the normal range despite variations in their nutritional status categories.³²

sCONCLUSION

Sweet taste threshold, sugar consumption patterns, and nutritional status were not associated with fasting blood glucose levels among adolescents. Future studies are encouraged to include other variables that may influence fasting blood glucose levels, such as physical activity, family history of diabetes mellitus, sleep quality, and stress levels. Furthermore, the use of experimental or case-control study designs is recommended to better explore causal relationships among variables in a more in-depth manner.

AUTHOR'S CONTRIBUTION STATEMENT

The contributions of each author are as follows: US designed the study, performed data collection, data analysis and interpretation, and wrote the original draft of the manuscript; SUH contributed to the study methodology, supervision, validation of research findings, and editing of the manuscript; ARMB contributed to the methodological review, data analysis, and critical revision of the manuscript; D contributed to the validation of research findings, data analysis, and editing of the manuscript. All authors have read and approved the final version of the manuscript.

CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest regarding this article. The authors confirm that there are no financial, personal, or professional relationships that could have influenced the conduct, results, or interpretation of this study. All aspects of the research were conducted independently and objectively, and no external interests influenced the preparation, submission, or publication of this article.

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