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The Relationship Between Sugar-Sweetened Beverage Consumption And Metabolic Syndrome Incidence In Adolescents: A Narrative Review

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Abstract

Metabolic syndrome in adolescents encompasses central obesity, hypertension, insulin resistance, and dyslipidemia, often associated with unhealthy lifestyles. In Indonesia, adolescents frequently consume sugar-sweetened beverages (SSBs), sometimes more than once a day, raising health concerns. This narrative review aims to examine the association between SSB consumption and the incidence of metabolic syndrome in adolescents. A literature search was conducted in PubMed, ScienceDirect, Google Scholar, and Springer using relevant keywords. Articles published between 2015 and 2025, written in English, and representing original research were included in this review. Evidence suggests that high SSB consumption is associated with an increased risk of metabolic syndrome. Frequent consumption contributes to central obesity through excess calorie intake. SSB consumption is also associated with insulin resistance, increased LDL and triglyceride levels, decreased HDL levels, and higher blood pressure. A dose-response pattern suggests that even moderate daily consumption (~90 ml) may increase risk over time. High SSB consumption contributes to the risk of metabolic syndrome among adolescents. Reducing consumption is crucial to prevent long-term metabolic disorders.

Keywords: Adolescents, Metabolic Syndrome, Sweetened Beverages.

INTRODUCTION

Metabolic syndrome has been identified as cardiometabolic and interrelated disorder which increases risk of cardiovascular disease and diabetes. (Melguizo-Rodríguez et al., 2021). Metabolic syndrome consists of central obesity, hypertension, insulin resistance and dyslipidemia (Weihe and Weihrauch-Blüher 2019). According to the International Diabetes Federation (IDF) 2023, an estimated 20-25% of the world's adult population is affected by metabolic syndrome, a condition that carries with it a significantly elevated risk of premature mortality, as well as a greater probability of cardiovascular complications, such as heart attacks and strokes, when compared to individuals not affected by metabolic syndrome. The prevalence of metabolic syndrome has been observed to vary according to age group. It is a lamentable fact that a significant proportion of adolescents in the present day already have metabolic syndrome, a condition that may include obesity and a range of comorbidities such as hypertension, dyslipidemia or insulin resistance (Luzzi et al., 2024). The prevalence rate of metabolic syndrome has been shown by several publications, ranging from 0.2% to 38.9% in the adolescent group (Al-Hamad & Raman, 2017). Metabolic syndrome can be caused by genetics, epigenetics, lifestyle and environment, such as overeating and lack of physical activity (Fahed et al., 2022). The lifestyle of adolescents in the consumption of food and beverages today needs to be a concern, especially the consumption of sugary drinks or commonly known as Sugar Sweetened Beverage (SSB).

Sugar Sweetened Beverage (SSB) is a sweetened beverage that contains simple sugars added during the production process to increase the energy content of the beverage (Buwana, 2023). The results of Basic Health Research (Riskesdas) in 2018 showed that 56.4% of adolescents aged 15-19 years in Indonesia consumed SSBs more than once per day and packaged tea as a type of SSB that is often consumed by adolescents (72%) and adults (61%) (Kemenkes, 2018;Laksmi et al., 2018). The high consumption of SSBs and the prevalence of metabolic syndrome in adolescents provided the

basis for this systematic review. The aim of the study is to determine the relationship between sugar sweetened beverage consumption and the incidence of metabolic syndrome in adolescents.

RESEARCH METHODS

This study is a narrative review with a focus on investigating the relationship between sugar sweetened beverage consumption and the incidence of metabolic syndrome in adolescents. Literature searches were conducted in PubMed, Science direct, Google scholar and Springer using several keywords, namely sugar-sweetened beverage, metabolic syndrome, adolescence, and teenager with Boolean operators (AND, OR) adjusted to each database. The inclusion criteria used in this study were articles with an adolescent population, published from 2015 to 2025, articles in English, and original research articles. Exclusion criteria used were articles that were not in English, meta-analysis articles, narrative review articles, systematic review articles and articles with qualitative studies. The selection of scientific articles was conducted with the following steps: first, abstracts of available literature were assessed (n = 200); second, the full text of potentially relevant articles was screened (n = 98); and third, relevant full-text articles were reviewed and analysed (n = 7).

RESULTS AND DISCUSSION

The present study is based on a literature review of seven studies conducted in several countries, including South Korea, Japan, Taiwan, China, Brazil, Iran, and Indonesia. The results of these studies were presented in Table 1, which examines the relationship between sugar-sweetened beverage consumption and the incidence of metabolic syndrome in adolescents. The seven studies outline the components of metabolic syndrome associated with sugar-sweetened beverage consumption. The common components of metabolic syndrome are known to include central obesity, hypertension, insulin resistance, and dyslipidemia (Weihe and Weihrauch-Blüher 2019). Research conducted on adolescents in urban areas in China, showed that adolescents who consumed high amounts of SSBs, had a 1.55 times higher risk of central obesity (Li et al. 2020). The study stated that the prevalence of metabolic syndrome was higher in adolescents who consumed high amounts of SSBs ($p = 0.038$) (Li et al. 2020). Another study on adolescents in Tehran also proved the association of high SSB consumption and the incidence of central obesity and metabolic syndrome (Mirmiran et al. 2015). Tehran adolescents who consumed high amounts of SSBs had a 2.97 times higher risk of central obesity ($p = 0.017$) and 3.16 higher risk of metabolic syndrome (Mirmiran et al. 2015). In a cohort study, it was found that there was an association between SSB consumption and the incidence of metabolic syndrome in adolescents in South Korea (Hur et al. 2015).

High consumption of SSBs increases the risk of central obesity, insulin, blood pressure, HDL, LDL, triglyceride, and fasting glucose levels. High school students in Semarang who had an average SSB intake of 92.5 g/day were in the high category, with an average triglyceride level of 113.9 mg/dL (Kartini et al. 2018). This finding is consistent with research conducted by Salustriano et al. (2024), which demonstrated a relationship between SSB consumption and elevated triglyceride levels ($p=0.004$). Concurrently, this relationship was accompanied by a decline in HDL-C levels, with a prevalence of metabolic syndrome in the adolescent population ($n=67$) of 56.7%. This finding aligns with the research conducted by Okuda, Fujiwara, and Sasaki (2020), which suggests that adolescents who consume added sugar from SSBs over 5% of their total energy intake may experience an increase in LDL levels, potentially leading to an elevated risk of cardiovascular events. The increase in blood lipid profile levels is attributable to the fructose content in SSBs, which is metabolised in the liver and leads to lipogenesis (Sari et al., 2024). Excessive Fructose consumption is known to result in its

metabolism into fat within the liver. This process leads to an augmentation of the liver's fat content, thereby prompting the organ to produce and secrete lipoproteins (VLDL). These lipoproteins can elevate the blood lipid profile (Malik and Hu, 2015). In addition to the affected blood lipid profile, there are blood pressure, insulin resistance, and fasting blood glucose levels that are affected due to excessive consumption of SSBs.

Consumption of SSBs more than 90 ml/day may lead to a 3-fold increased risk of metabolic syndrome, central obesity, and hypertension (Mirmiran et al. 2015). In a study conducted by Li et al. (2020) found evidence that adolescents who consumed high amounts of SSBs had high systolic and diastolic blood pressure. However, this is in contradiction with the research of Okuda, Fujiwara, and Sasaki (2020) who found that the continuous blood pressure variable was significantly associated with sugar intake, but the OR for high blood pressure was not significant which means that there is a significant relationship between blood pressure and sugar intake, but no significant risk of high blood pressure was found in adolescents who consume added sugar. The elevated blood pressure was caused by hyperuricemia due to the high intake of fructose from SSBs resulting in acute endothelial dysfunction and chronic Na retention which predisposes to hypertension (Farhangi, Nikniaz, and Khodarahmi 2020).

SSB consumption was also associated with the incidence of insulin resistance and increased fasting blood glucose levels. This was supported by the research conducted by Wu et al. (2021) revealed that there was a positive relationship between SSB intake, HOMA-IR, and cardiometabolic risk. In addition, it was explained that high intake consumption of SSB intake was consistent with high HOMA-IR value, indicating greater insulin resistance. In addition, a positive correlation was found between fasting blood glucose and consumption of sugary drinks ($r = 0,354$, $p = 0,003$) (Salustriano et al. 2024). However, the results of certain studies have failed to demonstrate a significant association between SSB consumption and fasting blood glucose levels in adolescents (Kartini et al. 2018). Insulin resistance (IR) arises from excessive sugar consumption, leading to elevated fat synthesis in the liver and adipose tissue. During lipogenesis, sugar is converted into detrimental products, such as diacylglycerols, which disturb insulin signalling and potentially induce insulin resistance (Ma et al. 2016).

Table 1. Result of The Literature Review

Author	Year	Study Design	Population Involved (Sample Size and Age)	Type of SSBs Studied	Main Results
Li, S., Cao, M., Yang, C., Zheng, H., & Zhu, Y.	2020	Cross-sectional	7143 children and adolescents aged 7–18 years	SSB include energy drinks, milk-containing drinks, soda, fruit drinks with added sugar, and other sugar-added beverages	Increased SSB intake was significantly associated with increased number of MetS components (Ptrend = 0.006) especially in abdominal obesity
Mirmiran, P., Yuzbashian, E., Asghari, G., Hosseinpour-Niazi, S., & Azizi, F.	2015	Population-based longitudinal	424 children and adolescents, aged 6–18 years	all kinds of sugar sweetened car-bonated soft drinks (SSSDs) and fruit juice drinks (both 100 % fruit juice and sugar sweetened synthetic juice drinks that are not 100 % juice)	Children and adolescents who consumed more than 90 ml/day (one-third serving) of SSBs had a 3-fold increased risk of MetS, abdominal obesity and hypertension
Evi Kartini, Fillah Fithra Dieny, Etisa Adi Murbawani, A.Fahmy Arif Tsani	2018	Cross-sectional	59 high school students	All type of sugar from packaged and non-packaged beverages	SSBs intake was associated with waist circumference, triglyceride levels, but not fasting blood glucose levels in adolescents.
Okuda, M., Fujiwara, A., & Sasaki, S	2020	Cohort	3242 students 8th grade	All kinds of sugar added in beverages, especially fruit juice, honey, and syrup	Consumption of added sugars in excess of 5% or 10% of total energy has an association with increased fasting blood glucose, LDL, and systolic blood pressure levels.
Salustriano , I. K., Tonetto Fernandes, V. de F., Colares Neto , G. de P., Costa Figueiredo	2024	Cross-sectional	67 adolescents, aged 10-19 years old	chocolate beverages, soft beverages, yogurts, dairy beverages, sweetened juices, artificial juices, teas and coffee	The prevalence of metabolic syndrome was 56.7% in adolescents. SSBs consumption was correlated with changes in waist circumference, BMI, systolic blood pressure, diastolic blood pressure, blood sugar, and triglycerides. SSBs consumption was associated

Author	Year	Study Design	Population Involved (Sample Size and Age)	Type of SSBs Studied	Main Results
, C., de Araújo Evangelista , N. M., & Landi Masquio, D. C					with lower HDL-c levels
Wu, PW., Tsai, S., Lee, CY. et al.	2021	Cross-sectional	1454 adolescents aged 12-16 years old	sweetened teas, soft drinks, sports drinks, and fruit drinks	High SSB consumption was associated with increased cardiometabolic risk, waist circumference, HOMA-IR values (indicating greater insulin resistance), and low HDL levels.
Hur, Y. I., Park, H., Kang, J. H., Lee, H. A., Song, H. J., Lee, H. J., & Kim, O. H.	2015	Cohort	770 student age 9-10 years old at baseline and 13-14 years old at follow up outcome	Fruit juice, fruit and vegetable drinks, carbonated beverages, sports drinks, coffee, sweet tea, soy milk, energy drinks, and other beverages	SSB consumption was positively related to Continuous Metabolic Syndrome Score (cMetS) which consisted of waist circumference, triglycerides, high-density lipoprotein cholesterol (HDLC), glucose, and mean arterial blood pressure (MAP).

CONCLUSION

The high consumption of sugar-sweetened beverages (SSBs) has been demonstrated to increase the risk of metabolic syndrome in adolescents, particularly in cases of central obesity. A substantial relationship has been demonstrated between sugar-sweetened beverage (SSB) consumption and elevated blood pressure, LDL, HDL, fasting blood glucose, insulin resistance, and diminished HDL levels. The limitations of this study are as follows: firstly, the definition of metabolic syndrome is subject to variation between studies; secondly, some studies employ the recall method or Food Frequency Questionnaire (FFQ), a method which has the potential to introduce bias. Furthermore, the association between SSB consumption and metabolic syndrome remains unclear, as no specific amount of SSB consumption has been identified that is definitively associated with the development of metabolic syndrome. A reduction in the consumption of sugar-sweetened beverages (SSBs) has been demonstrated to be a beneficial factor in the reduction of the risk of metabolic syndrome. Further research is required to ascertain the amount of SSB intake that can lead to metabolic syndrome.

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