

Characteristics of Adolescents with Pre-Metabolic Syndrome

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ABSTRACT

Metabolic syndrome is a cluster of metabolic disorders characterized by central obesity, elevated blood pressure, impaired glucose tolerance, insulin resistance, and increased triglyceride and LDL cholesterol levels. In 2017, the World Health Organization (WHO) stated that cardiovascular disease, a major manifestation of metabolic syndrome, was the leading cause of death globally. In Indonesia, the prevalence of metabolic diseases has also increased, particularly among children and adolescents, due to poor lifestyle habits. This study aimed to describe the characteristics of adolescents with metabolic syndrome. The study employed a quantitative descriptive design. Data were collected through anthropometric measurements, physical examinations, and blood sampling. Descriptive statistical analysis was used to analyze the data. The results showed that the average age of respondents was 16 years, the majority were female (53.3%), none had a history of drug use (100%), most did not smoke (56.7%), and most were in a pre-metabolic syndrome condition (90%). Additionally, 73.3% had normal blood pressure, 100% had normal random blood glucose levels, 60% had normal triglyceride levels, LDL cholesterol levels were normal, HDL cholesterol was normal in 93.3% of respondents, and 63.3% were categorized as underweight based on Body Mass Index (BMI).

Keywords: Adolescents, Cardiovascular Disease, Metabolic Syndrome

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INTRODUCTION

The World Health Organization (WHO) introduced the term "metabolic syndrome" in 2002. According to WHO, a person is diagnosed with metabolic syndrome if they meet at least three of the following five criteria: abdominal obesity, hypertriglyceridemia, low HDL (High-Density Lipoprotein) cholesterol, hypertension, and hyperglycemia. Individuals who meet only one of these criteria are considered to have pre-metabolic syndrome (1). In Indonesia, the most prominent components of metabolic syndrome include hypertension, hyperglycemia, and heart disease. The 2023 Indonesian Health Survey reported the prevalence of diabetes mellitus (DM) at 1.7%, heart disease at 0.85%, and hypertension at 8%, all of which indicate an increase compared to data from 2018 (3).

The exact cause of pre- or metabolic syndrome remains unclear. One hypothesis suggests that insulin resistance is the primary underlying mechanism of metabolic syndrome. Risk factors for metabolic syndrome include various life circumstances associated with the early development of disease, such as lifestyle (diet, alcohol consumption, smoking, and physical activity), socioeconomic status, genetic predisposition, and stress (4).

Adolescence is a critical period of growth and development that significantly influences future developmental stages (5). Adolescents are considered a vulnerable group for nutritional problems, particularly overnutrition. Several factors can contribute to overnutrition in adolescents, including rapid physical growth and increased nutritional needs.

Additionally, lifestyle changes and dietary habits directly affect daily nutrient intake (6). A study conducted in Semarang found that among 240 adolescents, 92.9% consumed insufficient fruits and vegetables, while 62.0% frequently consumed fatty foods and foods high in fructose.

The increasing incidence of pre- or metabolic syndrome has been linked to excessive fructose intake. Like other sugars, fructose rapidly elevates uric acid levels. Fructose is a simple sugar naturally found in honey and fruits but is often added to soft drinks, cakes, candies, and yogurt. Oral or intravenous fructose administration can increase serum uric acid levels within 30–60 minutes, and this effect may be sustained. Glucose and other simple sugars do not produce the same response. In the liver, fructose is converted to fructose-1-phosphate and adenosine triphosphate (ATP) by the enzyme fructokinase and subsequently to adenosine diphosphate (ADP). ADP derivatives are metabolized into various purine substrates. Rapid phosphate depletion, along with the action of adenosine monophosphate (AMP) deaminase, increases substrate availability for uric acid production. High uric acid levels can lead to endothelial dysfunction and reduce the bioavailability of endothelial nitric oxide (NO). This nitric oxide impairment contributes to insulin resistance and hypertension (7).

Based on these issues, this study aims to explore the characteristics of adolescents based on metabolic syndrome biomarkers.

METHODS

This study used a descriptive research design with a quantitative approach. A preliminary study was conducted

directly at Martapura Barat Public Health Center (Puskesmas) and SMAN 3 Martapura to gather information on the number of students, programs or activities previously conducted by the health center and the school related to students' physical health, and to observe the surrounding school environment located in a wetland area. The preliminary study was conducted from March 29 to 31, 2023.

The population of this study included all students enrolled at SMAN 3 Martapura, totaling 168 students from grades X, XI, and XII. A sample of 30 students was selected, in accordance with Cohen et al. (2007), who recommend a minimum sample size of 30 for quantitative research. The sampling technique used was simple random sampling. Inclusion criteria were students aged 16–18 years, actively enrolled at SMAN 3 Martapura in Sungai Rangas Village, Martapura Barat Subdistrict, and willing to participate as respondents.

The instruments used in this study included an observation sheet for physical examinations consisting of anthropometric measurements (height and weight) and metabolic biomarkers such as random blood glucose (RBG) levels and lipid profile (LDL, HDL, and triglyceride levels).

RESULTS AND DISCUSSION

Based on the demographic data of the respondents in this study, the majority were aged 15 years (33.3%) and 17 years (33.3%). Most respondents were female, totaling 16 individuals (53.3%). Kelishadi et al. (2013) reported that hormonal changes and fat accumulation in the central body region, especially during puberty, may be key factors contributing to the higher number of girls diagnosed with metabolic syndrome.

Table 1. Frequency Distribution of Demographic Data, Metabolic Syndrome Status, and Biomarkers (n = 30)

Variable	Frequency	Percentage (%)	Min-Max	Mean
Age				
15 Years	10	33.3	15-18	16.07
16 Years	9	30.0		
17 Years	10	33.3		
18 Years	1	3.3		
Gender				
Male	14	46.7	-	-
Female	16	53.3		
History of Drug Use				
Yes	0	0.0	-	-
No	30	100.0		
Smoking Status				
Yes	13	43.3	-	-
No	17	56.7		
Metabolic Syndrome Status				
Normal	2	6.7	-	-
Pre-Metabolic Syndrome	27	90.0		
Metabolic Syndrome	1	3.3		
Metabolic Syndrome Biomarkers				
Blood Pressure (BP)				
Low	4	13.3	85-158 54-102	114.6 69.6
Normal	22	73.3		
High	4	13.3		
Systolic BP				
Diastolic BP				
Random Blood Glucose (RBG)				
Normal	30	100.0	69-139	102
High	0	0.0		
Triglycerides				
Normal	18	60.0	58-414	160
High	12	40.0		
Low Density Lipoprotein (LDL)				
Normal	29	96.7	52-104	73
High	1	3.3		
High Density Lipoprotein (HDL)				
Low	28	93.3	25-62	36.35
Normal	2	6.7		
Body Mass Index (BMI)				
Underweight	19	63.3	14.2-25.5	18.73
Normal	10	33.3		
Overweight	1	3.3		

Another analysis by Friend, Craig, and Turner (2013) showed a higher prevalence of metabolic syndrome in boys compared to girls (5.1% vs. 3.0%, $p < 0.001$), and also in older children compared to younger ones (5.6% vs. 2.9%, $p = 0.001$), indicating a significant

association between metabolic syndrome, age, and gender.

A total of 13 respondents (43.3%) reported a history of smoking. Smoking behavior is known to be associated with the incidence of metabolic syndrome.

Tobacco Smoke Exposure (TSE) is a risk factor for cardiovascular diseases and refers to both active smokers (those who use tobacco products) and passive smokers (those who inhale smoke from burning tobacco products). Nearly 90% of adult smokers begin smoking before the age of 18 (8).

A study by Merianos et al. (2018) found that adolescents exposed to tobacco smoke, either as active or passive smokers, showed lipid biomarker abnormalities and were at risk of future cardiovascular issues. Smoke exposure increases peripheral white blood cell counts and inflammatory markers such as C-reactive protein, interleukin-6, and tumor necrosis factor-alpha. Consequently, smoke exposure triggers inflammation in the blood and vascular walls. Moreover, inhaling cigarette smoke alters lipid profiles and may trigger atherosclerosis. Smokers tend to have elevated levels of cholesterol, triglycerides, and LDL, while HDL levels are typically lower. Numerous studies have shown that direct exposure to cigarette smoke increases oxidative modifications of plasma LDL-C, which is pro-atherogenic and causes endothelial dysfunction (9,10).

In this study, the prevalence of pre-metabolic syndrome (90%) was higher than those with no metabolic syndrome components (6.7%) or with full metabolic syndrome (3.3%). Many researchers agree that pre-metabolic syndrome represents a condition where one or two criteria of full metabolic syndrome are met (11–13). The high prevalence of pre-metabolic syndrome requires attention to prevent progression into full metabolic syndrome, which is a major risk factor for cardiovascular disease and diabetes (14).

The assessment of metabolic syndrome status in this study was based on

biomarkers such as blood pressure, random blood glucose (RBG), triglycerides, LDL, HDL, and Body Mass Index (BMI). High blood pressure was found in 4 respondents (13.3%). Hypertension is known to be associated with high salt intake. Excessive salt increases intracellular calcium leakage, raising vascular smooth muscle tone and disrupting glucose homeostasis in beta cells via mechanisms involving ryanodine receptor type 2. High salt intake also promotes glucocorticoid production, which may lead to insulin resistance and metabolic syndrome (15). Indirectly, hypertension is also linked to diabetes mellitus, emphasizing the need to limit daily salt consumption.

Most respondents had one or two components of metabolic syndrome, placing them in the pre-metabolic syndrome category—specifically hypertriglyceridemia (40%) and low HDL (93.3%). Elevated triglycerides are a predictive factor for metabolic syndrome and an indicator of pre-metabolic syndrome (16). Haile, Haile, and Timerga (2021) found that 58% of patients with metabolic syndrome had at least one abnormal lipid profile, with 44% experiencing hypertriglyceridemia and 67.2% having low HDL levels. High triglyceride concentrations were statistically associated with central obesity, hypertension, high BMI, and elevated fasting blood glucose, while low HDL levels were associated with being overweight. These lipid abnormalities result from decreased clearance of lipoproteins in the bloodstream. Hepatic Lipoprotein Lipase (LPL) is an enzyme responsible for clearing triglyceride-containing lipoproteins, and insulin resistance has been linked to impaired LPL activity in individuals with metabolic syndrome (17).

Another notable finding in this study was that most respondents were underweight based on BMI, yet still exhibited potential indicators of metabolic syndrome (pre-metabolic syndrome). This could be due to inadequate nutritional intake in both quality and quantity. This aligns with Pamela (2018), who stated that adolescents tend to prioritize peer influence, hedonistic culture, and social environments over health when making choices, including dietary habits. Inadequate nutritional intake may disrupt the body's metabolic processes, leading to metabolic syndrome. Additionally, excessive intake without sufficient physical activity may contribute to the risk of developing degenerative diseases (18). The prevalence of fast food consumption is high among adolescents, both in public and private schools, due to its availability, affordability, taste, and convenience. Fast food typically contains high levels of sodium, which acts as a preservative, flavor enhancer, and appetite stimulant (19).

LIMITATIONS

A limitation of this study is the use of a descriptive design, which does not allow for analysis of relationships between variables. The findings are limited to describing sample characteristics and ordinal data without further explanation of potential causal or risk factors. Additionally, the study assessed smoking history but did not measure the extent of smoking behavior, such as whether respondents were active or passive smokers.

RESEARCH ETHIC

This study adhered to ethical research practices during data collection. Anonymity was maintained by using respondent initials only, without recording personal identifiers. Confidentiality was preserved, and all

information collected was kept secure. Participants were informed about the objectives and procedures of the study and were given the autonomy to decline participation without coercion. The study received ethical approval from the Ethics Committee of the Faculty of Medicine, Lambung Mangkurat University, with approval number: 15x/KEPK-FK ULM/EC/VII/2023.

CONFLICT OF INTEREST

The authors declare no conflict of interest in conducting this study. All necessary permissions and ethical approvals were obtained, and respondents were provided with sufficient information regarding the study's purpose and procedures.

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CONCLUSION

Among the 30 respondents in this study, the average age was 16 years, and the majority were female, had no history of smoking, and were in a pre-metabolic syndrome condition. The most frequently found components of metabolic syndrome among adolescents were hypertriglyceridemia, hypertension, and low HDL levels. Further research is necessary to analyze demographic variables in relation to metabolic syndrome biomarkers and to investigate family history of degenerative diseases, sleep quality, physical activity, and nutritional intake patterns among adolescents with pre-metabolic or full metabolic syndrome. Support from educational institutions, local health

offices, and public health centers is crucial for developing sustainable screening programs to help prevent non-communicable diseases in adulthood.

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