Early Detection Of Prediabetic and Risk Factors in Tomohon City High School Students

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Abstract: Diabetes Mellitus (DM) is a degenerative disease that is difficult to control, especially in this era due to lifestyle changes. DM is not only affected by adults but also increases in children and adolescents. DM is the cause of many severe complications, such as blindness, heart disease, kidney failure, and various infectious diseases that ultimately lead to premature death. Indonesia is among the top ten countries in the world, with a high prevalence of type 2 DM (T2DM) of 10.7 million cases. The 2018 Riset Kesehatan Dasar (Riskesdas) showed that the incidence of T2DM in Indonesia was 2%, in North Sulawesi 3%, and for ages 15-24 years 0.1%. The results of the same study in adolescents aged 15-24 years who experienced impaired fasting blood glucose (FBS) were 10.7%, and impaired glucose tolerance was 16.8%. High impaired blood glucose levels are an early sign of prediabetes in adolescents. This study aimed to determine and detect prediabetes in high school students in Tomohon City and the risk factors associated with prediabetes, including overweight and obesity, lack of physical activity, smoking, habits of consuming sweetened beverages, and family history. This study used a case-control design, with a sample of 17 high schools in Tomohon City, with a total of 5,461 students in grades X-XII. The sample was divided into two groups: a case group and a control group at a ratio of 1:3. The results of the study found that 25% of students experienced prediabetes, with three related risk factors: obesity and overweight (18.7%), lack of physical activity (4.7%), and habits of consuming sweetened beverages (19.6%). The dominant risk factor is based on the results; cooperation from various parties is expected to control students' lifestyles so that pre-diabetes will not develop into T2DM in the future.

Keywords: Prediabetes, Risk Factors, Students

INTRODUCTION

Prediabetes is a condition in which blood glucose levels are higher than normal but not enough to be diagnosed with diabetes mellitus (MohammadniaMotlagh et al., 2022). The diagnosis of prediabetes or diabetes is essential for determining the interventions to be performed to avoid complications that can cause disability and death (Shahouzehi et al., 2021). Diabetes mellitus develops progressively and chronically from prediabetes and occurs in all age groups, with worrying complications (Al-Zahrani et al., 2019). The increasing incidences of prediabetes and diabetes are closely associated with high morbidity and mortality rates (Li et al., 2021). The International Diabetes Federation (IDF) states that in 2021, there were 537 million

people in the world who had been diagnosed with diabetes, and it is estimated that the number of prediabetics exceeds the number of diabetics because many have not been detected (International Diabetes Federation, 2021). China, a developed country with the largest population in the world, has recorded 64.5 million people with pre-diabetes and 116.4 million people with diabetes mellitus (Li et al., 2021). Likewise, South Africa, which is still included in the category of developing countries, has recorded an increase in the incidence of diabetes in the population aged 20-79 years, which is 4.58 million people (Grundlingh et al., 2022).

Indonesia is ranked 5th in the world with a total of 19.5 million people with diabetes mellitus aged 20-79 years, and is estimated to increase to 28.6 million people in 2045 (International Diabetes Federation, 2021). In 2018, Riset Kesehatan Dasar (Riskesdas) stated that the prevalence of diabetes mellitus in people over 15 years of age in North Sulawesi Province was 3.04% (Kemenkes RI, 2018). In Tomohon City, based on the results of the Tomohon City Central Statistics Agency, diabetes mellitus ranks third out of the ten most common diseases in Tomohon City with 5055 cases, while prediabetes has not been recorded at all (BPS Kota Tomohon, 2018).

The incidence of prediabetes begins in childhood, adolescence, and adulthood, with various risk factors, including overweight and obesity, family history of diabetes mellitus, sedentary lifestyle, lack of physical activity, excessive calorie intake, and the habit of consuming additional sweetened beverages (Purba et al., 2021). Prediabetes is detected in 22-36% of children and adolescents who are obese, whereas the incidence of type 2 diabetes mellitus is most common in children and adolescents with a BMI of 35-39 kg/m2 (Bendor et al., 2020). Similar to a sedentary lifestyle and minimal physical activity, it greatly affects metabolic system disorders, such as diabetes mellitus (Mello et al., 2023). It has been proven that lack of physical activity can cause premature death due to health problems such as diabetes mellitus (Cavero-Redondo et al., 2017). High sugar consumption through drinks and foods is associated with an increased glycemic load (Werneck et al., 2021).

Changing habits and lifestyles in children and adolescents are closely related to the risk factors for prediabetes; therefore, it is important to carry out early detection of prediabetes and its risk factors in high school students in Tomohon City. This will be useful in planning further actions through preventive, promotive, and regulatory improvements to reduce the increase in the incidence of diabetes mellitus in the future.

METHOD

This was a case-control study. This study was conducted in high schools in Tomohon City from February to May 2024. The data collected included data on the incidence of prediabetes in high school students through fasting blood glucose (FBS), HbA1C, Oral Glucose tolerance tests (OGTT), questionnaires

to determine family history, consumption of sweetened beverages, and smoking habits. Physical activity was assessed by using the International Physical Activity (IPAQ) Questionnaire. Height and weight were measured for overweight and obesity, and the BMI per age formula was used to categorize overweight or obesity.

The number of high school students in Tomohon City is 5,461 students divided into 17 high schools. Based on blood glucose examinations, a population of prediabetes students was obtained as many as 98 students. The number of samples was determined using the Slovin formula (n = N / 1 + N (d) 2. A total of 79 samples were obtained from the case group. The sampling technique will use the Cluster Random Sampling technique. The total population divided by the number of schools (98/22 = 5 students per school) was the population of each school. The number of schools that will be the location of the study is 17 (the number of samples divided by the student population of each school is 79/5), which will be randomized for determination. Each school will take a sample of five prediabetes students, while for the control group, 237 students will be taken from 17 schools, with 15 students who are not prediabetes per school. Therefore, the ratio of the case and control group was 1:3. The control group will be matched with the case group according to sex and age, which is 16 years. The total number of respondents was 316 high school students.

The chi-square test was used to determine the relationship between prediabetes events and overweight and obesity, the relationship between prediabetes events and physical activity, the relationship between prediabetes events and smoking habits, the relationship between prediabetes events and family history of T2DM, and the relationship between prediabetes events and sweetened beverage consumption habits. Multivariate analysis using the logistic regression test followed by the Wald test was used to determine the significance of the logistic regression coefficient. The analysis was then continued with exponent B to determine which risk factors were most dominant in the relationship with prediabetes events in high school students.

RESULTS

The results of the univariate analysis of 316 respondents included gender, physical activity, consumption of sweetened beverages, smoking habits, obesity and overweight, family history, and prediabetes.

Table 1. Respondent Characteristics and Variables Of Study

No	Variable	Frequency (N= 316)	Percentage (%)
	Sex		
1	Male	211	66.8
	Female	105	33.2
	Physical Activity		
2	High	122	38.6
	Moderate	194	61.4
	Consumption Sweet Beverage		
3	Much	118	37.3
	Less	198	62.7
	Smoking Habit		
4	Smoker	108	34.2
	Non-smoker	208	65.8
	Overweight and Obesity		
5	Overweight and Obesity	171	54.1
	Normal	145	45.9
	Pre-diabetic		
6	Case (Pre diabetic)	79	25
	Control (Normal)	237	75
	Family History of T2DM		
7	With a family history	146	46.2
	Without a family history	170	53.8

The following are the results of a bivariate analysis of three risk factors associated with prediabetes: overweight and obesity, consumption of sweetened beverages, and physical activity based on a logistic regression test.

Table 2. Bivariate Analysis Between Pre-diabetic and risk factors

No	Variable		Pre-diabetic				ρ	OR
			Case (Pre-diabetic)	%	Control (Normal)	%		
1	Overweight and Obesity	Overweight and Obesity	59	18.7	86	27.2		
		Normal	20	6.3	151	47.8	0.000	0.193
	Total		79	25	237	75		
2	Consumption Sweetened beverages	Much	62	19.6	56	17.7		
		Less	17	5.4	181	57.3	0.000	11.788
	Total		79	25	237	75		
3	Physical activity	High	64	20.3	58	18.4		
		Moderate	15	4.7	179	56.6	0.000	13.168
	Total		79	25	237	75		

The calculation results for the modeling aimed at determining the variables related to prediabetes incidence were overweight and obesity variables with a value of p = 0.000; OR = 6.029, consumption of sweetened beverages with a value of p = 0.061; OR = 0.099, and physical activity, with a value of p = 0.000; OR = 3.311. The calculation results for the modeling are listed in Table 3.

Table 3. Result of Modelling

No	Variable	B	p-value	Exponent B	95% CI
1	Overweight and Obesity	1.787	0.000	6.029	2.861-12.709
2	Consumption Sweetened Beverages	-2.317	0.061	0.099	0.047-0.206
3	Physical Activity	-2.188	0.000	3.311	1.054-8.233
	Constanta	2.712	0.000		

When viewed from the Exponent B value for overweight and obesity, it is the most dominant variable related to the incidence of pre-diabetes in high school students in Tomohon City. High school students who are overweight and obese have a risk of pre-diabetes six times compared to students who have a normal body mass index.

Multivariate analysis, when entered into the logistic regression equation for each of these variables, the values obtained are:

$$P(x) = \frac{}{1 + e^{-[(a + b_1 (\text{Overweight and Obesity}) + b_2 (\text{Physical Activity})]}} \times 100\%$$

$$= \frac{1}{1 + 2{,}7182818^{-[1{,}722 + 1{,}508 + -2{,}489]}} \times 100\%$$

$$= \frac{1}{1 + 2{,}7182818^{[2{,}753]}} \times 100\%$$

$$= \frac{1}{1 + 15{,}6896} \times 100\%$$

$$= \frac{1}{16{,}6896} \times 100\%$$

$$= 16{,}6896 \times 100\%$$

$$= 16{,}68\ \%$$

From this equation, it can be predicted that if the two independent variables above do not match the expected conditions (respondents who have moderate physical activity and are overweight and obese), then it can be concluded that the risk of pre-diabetes is 17%.

DISCUSSION

The focus of this study is to know prediabetes and its risk factors in adolescents over ten years or after puberty, as an ADA recommendation. The family history, overweight and obesity, smoking habits, and consumption of sweetened beverages are the risk factors to have to know after screening of blood glucose level (Zuniga & Deboer, 2021). Being overweight and obese, lack of physical activity, and consumption of sweetened beverages have a significant impact on prediabetes in this study. The average fasting blood glucose in prediabetic students after fasting for 8 hours was 115 mg/dL, HbA1C 5.9%, and OGTT 165 mg/dL. The age of the students taken was 16 years old, with the number of male students 66.8% and female students 33.2%. Research in America also found that the increase in adolescents with prediabetes was higher in boys than girls, and the average age was 15.5 years (Ouyang et al., 2024).

One of the research in Kuwait is about overweight, and obesity can be prediabetes in adolescents 15-17 years of age, and the worst thing is it increases the level of LDL (Almari et al., 2021). In the same study in the USA, 128 adolescents with obesity have impaired glucose intolerance (16%) and develop T2DM in 3-5 years (Weiner et al., 2023). In this research, students who have prediabetes with overweight and obesity is 18.7%. A cohort study of adolescents with obese parents showed that these adolescents developed prediabetes over seven years. Most adolescents with obesity do not have symptoms, but if they are obese, prediabetes screening should be performed. (Ng & Chan, 2023). Obesity is chronic inflammation, and its signs with biomarkers like CRP, hs-CRP, TNF-α, IL-6, etc. TNF-α inhibits the activity of insulin receptors in target organs so that insulin does not reach the target organs while the pancreas continues to produce insulin. Thus, insulin resistance occurs (Salem, 2022).

Consuming sweetened beverages is proving to increase the risk of prediabetes in adolescents. Students who consume sweetened drinks experience prediabetes as much as 62%. They consume sweetened drinks every day more than 330 ml, such as sweet tea, soft drinks, boba drinks, etc. It is known that teenagers who frequently consume sweetened beverages have a high risk of not only prediabetes but also obesity (Park et al., 2023). However, the problem is that in Indonesia, there are no clear regulations regarding the sale and consumption of sweetened drinks for children and adolescents. Unfortunately, sweetened beverages are easily available anywhere and have a market share of children and teenagers, especially students.

Routine high physical activity has been shown to affect blood glucose balance. In Brazil, prediabetic adolescents had a sedentary lifestyle of 51.9%, moderate physical activity of 49.8%, and high physical activity of 46.4% (Sánchez-Martínez et al., 2023). Hyperglycemia is known to damage the endothelium of blood vessels, which can trigger various cardiovascular diseases. Adolescents with low to moderate physical activity and prediabetes have a higher risk of experiencing endothelial damage to blood vessels compared to adolescents with high physical activity (Vandercappellen et al., 2021). Based on this study, students with moderate physical activity have a risk of developing prediabetes three times greater than students with high physical activity.

CONCLUSION(S)

Based on the results of this study, of the five variables predicted to have a relationship with the occurrence of pre-diabetes in high school students, only three have a significant relationship, namely overweight and obesity, lack of physical activity, and the habit of consuming sweetened drinks. The most

dominant variables are overweight and obesity. Students who are overweight and obese are predicted to experience pre-diabetes six times more than students who have a normal body mass index.

Meanwhile, if students are overweight or obese and lack activity, it will increase the possibility of experiencing pre-diabetes by 17%.

Conflict of Interest

The author team hereby declares that the data published in the manuscript has no conflict of interest to any party. If in the future such a thing is found, full responsibility for it lies with the author.

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