The Relationship Between Sugar-Sweetened Beverage Intake, Physical Activity, Waist-Hip Ratio, and Fasting Blood Glucose Among Jenderal Soedirman University Students

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Abstract

Type 2 Diabetes Mellitus is increasingly prevalent among young adults, including university students, due to unhealthy lifestyle changes. Contributing risk factors include sugar-sweetened beverage consumption, low physical activity, and central obesity measured by waist-hip ratio (WHR). This study aimed to analyze the relationship between sugar-sweetened beverage intake, physical activity, and WHR with fasting blood glucose levels among students at Jenderal Soedirman University. This study used a quantitative analytical approach with a cross-sectional design. A total of 127 students aged 18–25 years were selected using purposive proportional sampling. Sugar-sweetened beverage intake was assessed using the Semi Quantitative-Food Frequency Questionnaire (SQ-FFQ), physical activity using the International Physical Activity Questionnaire-Short Form (IPAQ-SF), WHR using Bioelectrical Impedance Analysis (BIA) InBody 270, and fasting blood glucose levels using the Easy Touch GCU/GCHb device. The median sugar-sweetened beverage intake was 22.63 (0.62–102.34) g/day, and median physical activity was 891 (14.6–12880) MET-minutes/week. Mean WHR in males was 0.88±0.07, while median WHR in females was 0.84 (0.75–1). Mean fasting blood glucose was 97.35±7.73 mg/dL, with 37.8% categorized as prediabetes. No significant relationships were found between sugar-sweetened beverage intake, physical activity, or WHR and fasting blood glucose levels (p=0.429; p=0.477; p=0.073).

Keywords: Fasting Blood Glucose; Physical Activity; Students; Sugar-Sweetened Beverages; Waist-Hip Ratio.

I. INTRODUCTION

The mortality rate associated with Diabetes Mellitus among young adults increased from the eighth position in 2010 to the sixth position in 2019 (WHO, 2020). The national prevalence of prediabetes based on blood glucose measurements among individuals aged 15–24 years was 16.3% (Kemenkes, 2023). In 2024, the number of Diabetes Mellitus cases in Banyumas Regency reached 22,836, representing 1.23% of the population (DKK Banyumas, 2024).

University students can be categorized as young adults, generally ranging from 18 to 25 years of age. Sattu et al (2024) reported that university students tend to have lifestyles that may increase the risk of developing Type 2 Diabetes Mellitus. Risky lifestyle behaviors include frequent consumption of fast food, low levels of physical activity, smoking, and alcohol consumption. Prediabetes in young adults that is not adequately managed may progress to Type 2 Diabetes Mellitus within approximately 10 years (Sutton et al., 2018).

Environmental factors may contribute to the occurrence of Diabetes Mellitus among young adults. Along with changes in modern lifestyles, various instant products have become increasingly available, particularly packaged products with sweet flavors (Hana & Raida, 2022). The trend of consuming sugar-sweetened beverages among university students has also increased. A study by Ngizan & Iqbal (2023) involving 56 respondents found that 100% of university students consumed sugar-sweetened beverages. Frequent consumption of high

amounts of sugar is closely associated with Diabetes Mellitus and obesity (Santoso et al., 2021). Teng (2023) reported a significant relationship between Sugar-Sweetened Beverage (SSB) consumption and Fasting Blood Glucose (FBG) levels among university students. This condition may be related to increased adipose tissue accumulation in the abdominal region, which can contribute to obesity (Teng, 2023).

Another risk factor for Diabetes Mellitus is low physical activity. According to Ngizan & Iqbal (2023), 96.4% of university students had a high level of sedentary lifestyle. Physical activity is directly related to glucose regulation in the body. A study by Mare & Prasetiani, (2022) found a relationship between sedentary lifestyle and blood glucose levels among university students. During physical activity, glucose uptake by skeletal muscles increases, thereby contributing to a reduction in blood glucose levels. Insufficient physical activity is also related to obesity (Alza et al., 2020).

Obesity can be assessed using the waist hip ratio (WHR) (Ilmi & Utari, 2020). The risk of Diabetes Mellitus is related to a high WHR, defined as ≥0.85 in women and ≥0.90 in men (Sa'pang et al., 2018). Oktariza et al. (2021) found a positive and statistically significant relationship between WHR and fasting blood glucose levels. Abdominal fat accumulation may reduce the body's capacity to produce enzymatic antioxidants, which may subsequently exacerbate insulin resistance (Ria et al., 2017).

A preliminary study was conducted among Nutrition Science students at Universitas Jenderal Soedirman, class of 2022, in February 2025, involving 56 respondents. The results showed that 91.1% of students had low levels of physical activity, while 48.2% had WHR values categorized as high. Another study reported a prediabetes prevalence of 44.2% among university students, based on 52 respondents (Rahman, 2024). Based on these findings, further research is needed to examine the relationship between sugar-sweetened beverage intake, waist hip ratio, physical activity, and prediabetes among university students.

II. METHODS

Study Design and Setting

This study employed a quantitative descriptive-analytic approach with a cross-sectional design. The study was conducted at Universitas Jenderal Soedirman, with participants distributed across 12 faculties. Data collection was conducted from September 17 to October 6, 2025.

Population and Sample

The population in this study consisted of all registered and active undergraduate students at Universitas Jenderal Soedirman. Based on the Unsoed Dalam Angka (UDA, 2025), the total number of active undergraduate students was 28,006. The sample was selected using a purposive proportional sampling technique. The student population at Universitas Jenderal Soedirman was divided proportionally according to the number of students in each of the 12 faculties.

The inclusion criteria were active undergraduate students at Universitas Jenderal Soedirman, aged 18–25 years, and with no previous diagnosis of Diabetes Mellitus. The exclusion criteria were students who did not participate in data collection, withdrew from the study, did not complete the questionnaire, had fasting blood glucose levels ≥126 mg/dL, had a family history of Diabetes Mellitus, or were taking Diabetes Mellitus medication.

Based on the sample size calculation, 90 participants were required. An additional 10% was added to the calculated sample size to anticipate potential dropouts, resulting in a minimum sample of 99 undergraduate students.

Data Collection

Primary data were collected through interviews and direct measurements. Sugar-sweetened beverage intake was assessed using a Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ). Physical activity was measured using the International Physical Activity Questionnaire–Short Form (IPAQ-SF). Waist hip ratio (WHR) was measured using a Bioelectrical Impedance Analysis (BIA) device (InBody 270). Fasting blood glucose levels were measured using an Easy Touch GCU/GCHb device.

Data Analysis

Normality testing was performed using the Kolmogorov–Smirnov test because the number of respondents was greater than 40 (Emmanuel et al., 2020). A significance value of >0.05 indicated that the data were normally distributed, in which case parametric statistical analysis was performed. Univariate analysis was conducted to describe the characteristics of the respondents, including sex, age, body mass index (BMI), smoking habits, and the study variables, namely sugar-sweetened beverage intake, physical activity, waist hip ratio (WHR), and fasting blood glucose levels. The data were presented as frequencies and percentages. The distribution of each study variable was presented using descriptive statistics in the form of median and minimum–maximum (Min–Max) values.

Bivariate analysis was conducted to examine the relationship between sugar-sweetened beverage intake, physical activity, waist hip ratio, and fasting blood glucose levels using the Spearman rank correlation test (rs), as the data were not normally distributed.

Research Ethics

This study received ethical approval from the Health Research Ethics Committee, Faculty of Health Sciences, Universitas Jenderal Soedirman, under the research project entitled "Nutritional Status Indicators for Early Detection of Pre-Metabolic Syndrome in Young Adults", with ethical approval number 1924/EC/KEPK/VIII/2025.

III. RESULTS AND DISCUSSIONS

A. Result

The study examining the relationship between sugar-sweetened beverage intake, waist-hip ratio, physical activity, and fasting blood glucose levels among students at Universitas Jenderal Soedirman was conducted at the Nutrition Education and Counseling Laboratory and the Nutrition Biomedical Laboratory, IHSB Building, Faculty of Health Sciences, Universitas Jenderal Soedirman, from September 17 to October 6, 2025.

A total of 278 individuals registered for the study. Following the screening process, 156 respondents met the study eligibility criteria. Twenty respondents did not attend the data collection session, resulting in 136 respondents who participated in data collection. After several dropouts, the final number of respondents included in the analysis was 127.

Respondent Characteristics

The characteristics of the respondents included sex, age, body mass index (BMI), and smoking habits. The characteristics of the respondents are presented in Table 1. Based on Table 1, the respondents characteristics were classified according to sex, age, body mass index (BMI), and smoking habits. A total of 127 respondents participated in this study, comprising 29.1% males and 70.9% females. The majority of respondents (85%) were aged 18–21 years. Regarding BMI, most respondents (53.5%) had a normal BMI, while 21.2%

were classified as obese. In terms of smoking habits, the majority of respondents (86.6%) reported that they did not smoke, whereas 13.4% reported smoking.

Table 1. Respondents characteristics

Respondent Characteristics	Frequency (n)	Percentage (%)
Sex		
Male	37	29,1
Female	90	70,9
Age *		
18-21	108	85
22-24	19	15
Body Mass Index (BMI)**		
Underweight (BMI <18,5)	22	17,3
Normal (BMI 18,5-22,9)	68	53,5
Overweight (BMI 23-24,9)	10	7,9
Obesitas I (BMI 25-29,9)	20	15,7
Obesitas II (BMI ≥30)	7	5,5
Smoking Habits		
Non-smoker	110	86,6
Smoker	17	13,4
Total	**127**	**100**

((Santrock, 2007) *; (KEMENKES, 2025)**)

Sugar-Sweetened Beverage Intake

Data on respondents' sugar-sweetened beverage (SSB) intake were assessed based on their average daily sugar intake over the preceding month, using a semi-quantitative food frequency questionnaire (SQ-FFQ). In Indonesia, the recommended maximum sugar intake is 50 g per day, whereas the Spanish Agency for Food Safety and Nutrition (AESAN) recommends a more stringent limit of approximately 30 g per day. This lower threshold is considered more protective in reducing blood glucose spikes, body fat accumulation, and the risk of non-communicable diseases. Therefore, adopting a stricter sugar intake limit, such as that recommended by AESAN, may be more appropriate for reducing health risks among the Indonesian population, which is suggested to be genetically and physiologically more sensitive to excessive sugar intake (AESAN, 2020). The SSB intake data were not normally distributed, therefore, the data are reported as the median. The frequency distribution of SSB intake is presented in Table 2.

Table 1. Frequency distribution and median of sugar-sweetened beverage intake

Sugar-Sweetened Beverage Intake Category*	Frequency (n)	Percentage (%)	Median (Min-Max) (g)
Normal (<30 g)	78	61,4	22,63 (0,62-102,34)
Above the recommended limit (≥30 g)	49	38,6	

(AESAN, 2020)*

As shown in Table 2, the median daily sugar intake from sugar-sweetened beverages among respondents was 22.63 g. The minimum and maximum values were 0.62 g and 102.34 g, respectively. Most respondents (61.4%) had sugar-sweetened beverage intake within the normal range, whereas 38.6% exceeded the recommended limit. The ranking of the most frequently consumed sugar-sweetened beverages among respondents presented in Table 3.

Table 2. Most Frequently Consumed Sugar-Sweetened Beverages

Type of Beverage	Average Daily Sugar Intake (g)	Consumption Frequency (times/month)
Sweetened tea	7,09	3x
Fruit juice	2,83	2x
Susu ultramilk	1,12	1x

Iced orange juice	0,93	2x
Matcha latte	0,45	1x

Physical Activity

Physical activity data were collected using the International Physical Activity Questionnaire–Short Form (IPAQ-SF), which assessed respondents' physical activity over the preceding seven days. The IPAQ-SF is designed to assess physical activity among adults aged 15–69 years, including university students who generally fall within this age range (Mulyasari & Srimiati, 2020). Physical activity levels were calculated in metabolic equivalents of task (METs). The physical activity data were not normally distributed, therefore, the data are presented as the median. The frequency distribution of physical activity is presented in Table 4.

Table 4. Frequency Distribution and Median of Physical Activity

Kategori Aktivitas Fisik *	Frekuensi (n)	Persen (%)	Median (Min-Max)
Low (<600 MET)	46	36,2	891 (14,6-12880)
Moderate (≥600-3000 MET)	65	51,2	
High (>3000 MET)	16	12,6	

(YOUTHREX, 2019)*

As shown in Table 4. the median physical activity level was 891 MET-min/week, with a minimum value of 14.6 MET-min/week and a maximum value of 12,880 MET-min/week. Most respondents (51.2%) had a moderate level of physical activity, while 36.2% were classified as having a low level of physical activity. The average duration of physical activity is presented in Table 5.

Table 5. Average Duration of Physical Activity

IPAQ Component	Average Duration (min/day)
High-intensity physical activity (<600 MET)	33,9
Moderate physical activity (≥600-3000 MET)	26,41
Walking (>3000 MET)	37,09
Sitting time	266,8

(YOUTHREX, 2019)

Waist-Hip Ratio

Waist-to-hip ratio (WHR) data were analyzed separately for males and females because the classification criteria differ by sex. The WHR data for males were normally distributed, therefore, the results are presented as the mean. In contrast, the WHR data for females were not normally distributed, therefore, the results are presented as the median. The frequency distribution of WHR is presented in Table 6.

Table 6. Frequency Distribution and Mean WHR

Kategori Waist-Hip Ratio*	Frekuensi (n)	Persen (%)	Mean±SD
Male			
Under (<0,80)	5	13,5	0,8816±0,07259
Normal (0,80-0,90)	21	56,8	
Over (>0,90)	11	28,7	
Female			
Under (<0,75)	1	1,1	0,84 (0,75-1)
Normal (0,75-0,85)	58	64,4	
Over (>0,85)	31	34,4	

(InBody Asia, 2022)*

As shown in Table 4.6, the mean WHR among male respondents was 0.8816 ± 0.07259. The most prevalent category was normal WHR (56.8%), while 28.7% of male respondents had a high WHR. Among female respondents, the median WHR was 0.84, with a minimum

value of 0.75 and a maximum value of 1.00. The most prevalent category among female respondents was normal WHR (64.4%), while 34.4% had a high WHR.

Fasting Blood Glucose

Fasting blood glucose levels were measured using capillary blood samples obtained from the fingertip. The fasting blood glucose data were normally distributed, therefore, the results are presented as the mean. The frequency distribution of respondents' fasting blood glucose levels is presented in Table 7.

Table 7. Frequency distribution of fasting blood glucose levels

Fasting Blood Glucose Category*	Frequency (n)	Percentage (%)	Mean±SD
Normal (<100)	79	62,2	97,35±7,732
Prediabetes (100-125)	48	37,8	

(Perkeni, 2024)*

Most respondents had fasting blood glucose levels within the normal range (62.2%), while 37.8% had fasting blood glucose levels in the prediabetes range. The duration of fasting among respondents is presented in Table 8.

Table 8. Fasting duration of respondents

Fasting Duration	Frequency (n)	Percentage (%)
8 hours	59	46,5
> 8 hours	68	53,5

Relationship Between the Independent Variables and Fasting Blood Glucose Levels

Bivariate analysis was performed using Spearman's rank correlation test because the data for sugar-sweetened beverage intake, waist-to-hip ratio (WHR), and physical activity were not normally distributed. The relationships between the independent variables and the dependent variable are presented in Table 9.

Table 9. Relationship Between the Independent Variables and Fasting Blood Glucose Levels

Independent Variable	Dependent variable	*p value*	*r value*
Sugar-sweetened beverage intake	Fasting blood glucose	0,429	0,071
Physical activity	Fasting blood glucose	0,477	-0,064
Waist-to-hip ratio (WHR)	Fasting blood glucose	0,073	0,064

As shown in Table 4.9, there was no statistically significant relationship between sugar-sweetened beverage intake and fasting blood glucose levels ($p = 0.429$; $p > 0.05$), with a correlation coefficient (r) of 0.071. This coefficient indicates a very weak positive relationship, suggesting that higher sugar-sweetened beverage intake tended to be associated with higher fasting blood glucose levels. Similarly, no statistically significant relationship was found between physical activity and fasting blood glucose levels ($p = 0.477$; $p > 0.05$), with a correlation coefficient (r) of -0.064. This indicates a very weak negative relationship, suggesting that higher physical activity levels tended to be associated with lower fasting blood glucose levels. Furthermore, no statistically significant relationship was observed between WHR and fasting blood glucose levels ($p = 0.073$; $p > 0.05$), with a correlation coefficient (r) of 0.064. This indicates a very weak positive relationship, suggesting that a higher WHR tended to be associated with higher fasting blood glucose levels.

B. Discussion

Respondent Characteristics

Based on sex, the majority of respondents in this study were female, accounting for 70.9% of the total respondents. This finding is consistent with a previous study by Komariah & Rahayu (2020), which found that the majority of patients with Type 2 Diabetes Mellitus were female. Women are considered more susceptible to developing diabetes because, physiologically, they tend to have a greater potential for increases in body mass index compared with men.

The results showed that most respondents were aged 18–21 years, accounting for 85% of the total respondents. Individuals aged 18–21 years are generally categorized as being in late adolescence, which represents a transitional stage toward adulthood. At this stage, individuals begin to develop greater autonomy and may live separately from their parents. Consequently, their dietary patterns and physical activity are increasingly determined by personal choices rather than depending on others (Wigiyandiaz et al., 2020).

Based on body mass index (BMI), the results showed that the BMI of most respondents was within the normal category, accounting for 53.5%, while 21.2% of respondents were classified as obese. Obesity and overweight are associated with an increased risk of developing Diabetes Mellitus. Therefore, maintaining and controlling body weight is an important step in preventing the progression of prediabetes to Diabetes Mellitus (Sa'pang et al., 2018).

Regarding smoking habits, the results showed that the majority of respondents were non-smokers, accounting for 86.6%. Long-term active smokers tend to have lower insulin receptor sensitivity. Even after discontinuing smoking for 1–2 weeks, insulin sensitivity generally does not immediately return to normal levels (Chairunnisa, 2020). Nicotine affects insulin function by reducing insulin secretion through the activation of catecholamine hormones, which negatively affects insulin function. This condition may subsequently impair pancreatic beta-cell function and contribute to the development of insulin resistance (Chairunnisa, 2020).

Sugar-Sweetened Beverage Intake

The results showed that the median sugar-sweetened beverage intake, based on the amount of sugar consumed, was 22.63 grams per day. This finding indicates that the respondents generally had sugar-sweetened beverage intake within the recommended range (<30 g/day) (AESAN, 2020). A study by Jayanti et al (2021) also showed that respondents tended to have sugar-sweetened beverage intake within the normal range. Based on the findings, the most frequently consumed beverage among the respondents was sweetened tea, with sugar derived from granulated sugar at approximately 20 grams per glass. The average sugar intake from sweetened tea was 7.09 grams per day, with the most common consumption frequency being three times per month, which was categorized as infrequent consumption (Khofifah et al., 2024).

Physical Activity

The results showed that the median physical activity level was 891 MET-minutes/week, indicating that the respondents generally had a moderate level of physical activity (600–3,000 MET-minutes/week) (YOUTHREX, 2019). This finding is consistent with a study by Mufidah & Soeyono (2021), which showed that university students tended to have moderate levels of physical activity.

The physical activity component with the longest duration was sitting, with an average duration of 4.45 hours per day. This finding indicates that the respondents generally had a

moderate level of sedentary lifestyle, categorized as 2–5 hours per day (Qosim & Artanti, 2023). University students tend to spend considerable amounts of time sitting because their daily activities involve attending lectures in classrooms. Therefore, the physical activity recommendations issued by the Indonesian Ministry of Health include moderate-intensity physical activity, such as brisk walking for at least 150–300 minutes per week, or vigorous-intensity physical activity, such as running for at least 75–150 minutes per week (KEMENKES, 2025).

Waist-Hip Ratio

The results showed that the mean waist-hip ratio among male respondents was 0.8816 ± 0.07259. The most common category of waist-hip ratio among males was normal, accounting for 56.8%, while 28.7% had an over-category waist-hip ratio. Among female respondents, the median waist-hip ratio was 0.84, with a minimum value of 0.75 and a maximum value of 1.00. The most common category of waist-hip ratio among females was normal, accounting for 64.4%, while 34.4% had an over-category waist-hip ratio.

These findings are consistent with a study by Sunanda Putra & Junita (2022), which showed that adolescent respondents tended to have a normal waist-hip ratio. Waist-hip ratio is used to assess central obesity and can serve as a more accurate indicator of central obesity than BMI (Sirada et al., 2025). A high waist-hip ratio indicates fat accumulation in the abdominal region, which is often associated with an increased risk of metabolic disorders such as Type 2 Diabetes Mellitus, hypertension, and dyslipidemia (Hariri et al., 2024).

Fasting Blood Glucose

The results showed that the mean fasting blood glucose level among the respondents was 97.35 ± 7.732 mg/dL, indicating that the average fasting blood glucose level was within the normal range (PERKENI, 2024). This finding is consistent with a study by Rahman (2024), which showed that fasting blood glucose levels among university students tended to be within the normal range.

In younger individuals, carbohydrate metabolism and organ function are generally still operating optimally. Blood glucose levels reflect the ability of the pancreas to secrete insulin and the effectiveness of glucose uptake by target tissue cells (Putra et al., 2015). Before fasting blood glucose measurements were taken, respondents were instructed to fast for at least 8 hours. During fasting, blood glucose levels decrease, followed by a reduction in insulin secretion. This condition stimulates an increase in the activity of counter-regulatory hormones, such as catecholamines and glucagon, which play a role in glycogen breakdown. Therefore, fasting blood glucose measurements can provide a more sensitive assessment of insulin function in the body (Hita & Bakta, 2024).

Relationship between Sugar-Sweetened Beverage Intake and Fasting Blood Glucose Levels

The results showed that the relationship between sugar-sweetened beverage intake and fasting blood glucose levels had a p-value of 0.429. Therefore, it can be concluded that there was no relationship between sugar-sweetened beverage intake and fasting blood glucose levels ($p>0.05$). This finding is consistent with a study by (Akbar & Giyaningtyas, 2023), which reported no relationship between sugar-sweetened beverage intake and blood glucose levels among adolescents. The median sugar-sweetened beverage intake, based on the amount of sugar consumed, was 22.63 grams per day. This result indicates that the respondents generally had sugar-sweetened beverage intake within the normal range (<30

grams/day) (AESAN, 2020). Therefore, the respondents' sugar-sweetened beverage intake had not yet become a high-risk factor for the development of prediabetes.

Sweetened tea was the most frequently consumed beverage among the respondents. The sugar in sweetened tea came from granulated sugar, with approximately 20 grams per glass. The average daily sugar intake from sweetened tea was 7.09 grams, with the most common consumption frequency being three times per month, which was categorized as infrequent consumption (Khofifah et al., 2024). A study by Verdiana & Nurjana (2019) stated that infrequent consumption of sweet foods and beverages could reduce the risk of Diabetes Mellitus.

A total of 22.8% of respondents had high sugar-sweetened beverage intake but had fasting blood glucose levels within the normal range. This may have been due to the respondents fasting for longer than the recommended duration, namely more than 8 hours. Blood glucose levels return to fasting levels approximately two hours after eating; therefore, prolonged fasting may result in further decreases in blood glucose levels (Wahyudi, 2013).

Another finding of this study was that 22% of respondents had sugar-sweetened beverage intake within the normal range but had fasting blood glucose levels categorized as prediabetes. This finding indicates that some individuals with normal sugar-sweetened beverage intake may already have a tendency toward prediabetes. Therefore, it is recommended to maintain daily sugar intake according to the recommended level (<30 g/day) (AESAN, 2020).

In this study, the method used to assess respondents' sugar-sweetened beverage intake was the SQ-FFQ. This instrument has several challenges, as it requires respondents to provide honest responses and have sufficient motivation when answering the questions. In addition, the long list of foods and beverages in the SQ-FFQ may make it difficult for respondents to estimate the portion sizes consumed (Saputri, 2025). Food portions with non-uniform shapes tend to be more difficult to estimate than foods that are consumed regularly with clearly defined serving sizes. Therefore, a gold-standard method that can assess respondents' sugar-sweetened beverage intake more specifically, such as the food record method, is needed (Saputri, 2025).

Sugar-sweetened beverage consumption has been shown to have negative effects on the mechanisms regulating hunger and satiety. Another factor that was not examined in this study was energy density. Consumption of beverages containing added sweeteners may lead to earlier feelings of hunger and increase energy intake. Therefore, the relationship between sugar-sweetened beverages and Type 2 Diabetes Mellitus is largely influenced by excessive energy intake rather than by the glycemic index directly (Veit et al., 2022).

Relationship between Physical Activity and Fasting Blood Glucose Levels

Based on the results, the relationship between physical activity and fasting blood glucose levels had a p-value of 0.477. Therefore, it can be concluded that there was no relationship between physical activity and fasting blood glucose levels. This finding is consistent with a previous study by Silvia & Faridi (2024), which showed no relationship between physical activity and blood glucose levels. The median physical activity level of the respondents was 891 MET-minutes/week, indicating that the respondents generally had a moderate level of physical activity (600–3,000 MET-minutes/week) (YOUTHREX, 2019). Therefore, physical activity had not yet become a high-risk factor for the development of prediabetes.

The results showed that 20.5% of respondents had low physical activity but had fasting blood glucose levels within the normal range. In this study, sitting time was not included in the calculation of the respondents' total MET-minutes. Although the respondents generally had moderate levels of physical activity, they also tended to have a sedentary lifestyle, with the longest average duration of activity being sitting, at 4.45 hours per day. In this study, the types of physical exercise performed by the respondents were also not identified, which may

have influenced the fasting blood glucose measurements. A study by Melchalida (2011) used the IPAQ-SF questionnaire to estimate respondents' physical activity levels. However, the use of this instrument may potentially introduce data bias, as respondents may sometimes tend to overestimate the level of physical activity they perform.

Another finding was that 17.3% of respondents had moderate-intensity physical activity but had fasting blood glucose levels categorized as prediabetes. Therefore, individuals with moderate physical activity may still have a tendency toward prediabetes. Accordingly, respondents are recommended to engage in physical activity for at least 150–300 minutes per week at moderate intensity, such as brisk walking, or at least 75–150 minutes per week at vigorous intensity, such as running (KEMENKES, 2025).

Sustained physical activity requires a stable supply of energy to support cellular physiological processes. Energy is obtained from the metabolism of carbohydrates and body fat into adenosine triphosphate (ATP), with the contribution of each energy source depending on the intensity of physical activity (Sarifin et al., 2021). Therefore, although physical activity plays a role in controlling blood glucose levels, its effects may not be clearly observed in individuals with good metabolic conditions (Azitha et al., 2018).

Relationship between Waist-Hip Ratio and Fasting Blood Glucose Levels

The results showed that the relationship between waist-hip ratio and fasting blood glucose levels had a p-value of 0.073. These results indicate that there was no relationship between waist-hip ratio and fasting blood glucose levels. This finding is consistent with a study by Ilmi & Utari (2020), which showed no relationship between waist-hip ratio and fasting blood glucose levels among university students. The mean waist-hip ratio among male respondents was 0.8816 ± 0.07259, while the median waist-hip ratio among female respondents was 0.84, which was within the normal range of 0.80–0.90 for males and 0.75–0.85 for females (InBody Asia, 2022). Therefore, waist-hip ratio had not yet become a high-risk factor for the development of prediabetes.

The results showed that 18.9% of male respondents and 17.8% of female respondents had an over-category waist-hip ratio but had fasting blood glucose levels within the normal range. In this study, the duration of obesity among the respondents was not assessed. In addition to the severity of obesity, the duration of a history of obesity may also influence the development of Type 2 Diabetes Mellitus (Mulyani & Rita, 2016). Therefore, this factor may have influenced the results of the respondents' measurements.

Another finding was that 16.2% of male respondents and 23.3% of female respondents had a normal waist-hip ratio but had fasting blood glucose levels categorized as prediabetes. This finding indicates that individuals with a normal waist-hip ratio may already have a tendency toward prediabetes. Therefore, maintaining the waist-hip ratio within the normal range, namely 0.80–0.90 for males and 0.75–0.85 for females, is recommended (InBody Asia, 2022).

Males may have a higher risk of developing prediabetes because they tend to accumulate fat in the abdominal region or develop central obesity. Females may also have a risk of developing prediabetes related to their higher body fat composition. However, at a younger age, the hormone estrogen plays an active role in regulating the body's insulin sensitivity (Yunita et al., 2022). Therefore, young adults, particularly males, are recommended to maintain their waist-hip ratio within the normal range to help prevent the risk of prediabetes.

Waist-hip ratio is a chronic risk factor. At a younger age, carbohydrate metabolism and organ function are generally still operating optimally. Blood glucose levels reflect the ability of the pancreas to secrete insulin and the effectiveness of glucose uptake by target tissue cells (Putra et al., 2015). Physiologically, Type 2 Diabetes Mellitus begins with insulin resistance. Initially, the pancreas responds to this condition by increasing insulin secretion to maintain blood glucose levels within the normal range. However, at a later stage, pancreatic cell

dysfunction and exhaustion result in a gradual decrease in insulin production, leading to fasting hyperglycemia of varying severity (Mulyani & Rita, 2016).

I. CONCLUSION

Statistical analysis revealed no statistically significant relationships between sugar-sweetened beverage intake, physical activity, or waist-to-hip ratio (WHR) and fasting blood glucose levels among the respondents.

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