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Intake of Sugar-Sweetened Beverage and Metabolic Syndrome Components in Adolescents

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Abstract

Background: Adolescents with metabolic syndrome have a higher risk for cardiovascular diseases and diabetes. Risk factors of metabolic syndrome include central obesity, hypertriglyceridemia, and hyperglycemia. High intake (>50 g/day) of sugar-sweetened beverages (SSB) is known to be positively associated with increased waist circumference, triglyceride levels, and fasting blood glucose levels. This study aimed to analyze the relationship between sugar-sweetened beverage intake with waist circumference, triglyceride levels, and fasting blood glucose levels in adolescents.

Methods: This was a cross-sectional study with fifty- nine subjects of adolescents aged 15-18 years old that chosen by simple random sampling technique. Food intake was assessed with Semi Quantitative Food Frequency Questionnaire, while waist circumference used a tape measure. Blood glucose levels were measuredwith Glucose Oxidation method, triglyceride levels using colorimetric enzymatic method (GPO-PAP). Data were analyzed using r Pearson and Rank-Spearman test.

Results:The Mean waist circumference was 79.9±12.6 cm, mean triglyceride levels was 113.9±10.3 mg/dL, mean fasting blood glucose levels was 81.5±7.6 mg/dL, and mean intake of SSB was 92.5±60.8 g. High triglyceride levels were observed in 62.7% subjects and total of 44.11% subjects had large waist circumference. Excessive intake of SSB was found in 72.9% subjects. Intake of sugar-sweetened beverages was linked with waist circumference (p=0.020) and triglyceride levels (p=0.044), but not fasting blood glucose levels (p=0.060).

Conclusions: Consumption of sugar-sweetened beverages >50 g/day can increased waist circumference and triglyceride levels, that are component of metabolic syndrome.

Keywords: Sugar-Sweetened Beverage, Metabolic Syndrome, Adolescents

INTRODUCTION

Metabolic syndrome is a metabolic disorder which increase cardiovascular diseases and diabetes mellitus. The components of metabolic syndrome are central obesity, the increase of triglyceride level and fasting blood glucose, HDL level decrease and also high blood pressure (Alberti, et al, 2009). The increase of metabolic syndrome prevalence on adolescents along with the increase of obesity prevalence as one or the risk of metabolic syndrome (Weiss, et al, 2004). Based on stud result in Semarang city in 2015 shows that the prevalence of metabolic syndrome in obese adolescents as 68.4% (Dieny,et al 2015). The research conducted in SMAN 15 Semarang in 2016 showed that from 66 obese adolescents, there were 47.5% has metabolic syndrome (Muhammad, Dieny, 2016).

Obesity is the main trigger of metabolic syndrome on adolescents because excess calorie intake from carbohydrate, fat, and protein more than total energy needed (Santos, et al, 2005). The excess energy will be convert into fat and stored in adipose tissue which will increase waist circumference (Oktaviani, et al, 2012). Adolescents with central obesity has waist circumference for more than 80th percentile. Obesity can trigger the increase of triglyceride by excess fat storing. Triglyceride accumulation in hepar can cause insulin resistance which will increase fasting blood glucose (Dieny et al, 2015)

Consumption sugar-sweetened beverage increases on adolescents because it is affected by several factors, those are: advertisements broadcasted in media, peer group influences, and distribution of sugar-sweetened beverage in accessible cafeteria or supermarket (Robert, 2011), (Flood, et al, 2006). Sugar-sweetened beverage is a beverage of which has been added calorie sweetener into it, such as soft drink, sport drink, fruit drink, energized drink, tea and coffee, milk, fruit juice, and isotonic beverage (CDC, 2010). Based on the study of cohort conducted on adolescents showed that the consumption of sugar-sweetened beverage for 375 ml which contain sugar approximately 37-54 g contribute energy as 150 calories which related to the increase of metabolic syndrome risk (Barrio, et al 2013), (Wang, et al, 2008). The additional sugar content in sugar-sweetened beverage contributes energy as 21.2% on adolescents which can increase obesity Excess energy in the body will be stored in a form of triglyceride in depose tissue which lead to obesity if it is occur continuously (Barquera, et al, 2008), (Febriyani, et al, 2012). The study on female adolescents aged 12-19 showed the consumption of *sugar-sweetened beverage* 250g/day will lead to the increase of triglyceride as 2,3mg/Dl (Chan, et al, 2014). Another study stated that the consumption of *sugar-sweetened beverage* > 1 portion per day can increase the prevalence of diabetes mellitus type 2 as 26% (Malik, 2012). Based on the background the author interested to analyze the correlation of sugar-sweetened beverage intake with waist circumference, triglyceride and fasting blood glucose on adolescents.

RESEARCH METHOD

This survey study used a cross sectional design with data collecting on July until August 2017. This study was conducted on students old in SMA Negeri 15 semarang. The selection of 59 subjects was performed by simple random sampling technique. Data on age, subjects identity, antropometri, sugar sweetened beverage (SSB) intake, energy intake, waist circumference, triglyceride level, and fasting blood glucose level.

Waist circumference is the circle line of a waist right on navel measured through the middle of lowest interior edge with crista iliaca. The category of central obese waist circumference if the waist circumference is more than 80 cm and normal if it less then 80. Fasting blood glucose levels (GDP) are a parameter that describes the glucose concentration in the blood plasma measured in subjects who were fasting for 8-12 hours. GDP levels were measured using spectophotometry by the Glucose Oxidation (GOD) method. GDP levels are considered to be high if it is ≥100 mg / dL and normal if it is ≤100 mg / dL.8 Triglyceride was one of the fats in the bloodstream that come from fat intake and were formed in the liver. Triglyceride levels were measured by enzymatic colorimetric using glycerol phosphate oxidase (GPO). Triglyceride levels is considered high if it is ≥110 mg /dL and normal if it is <110 mg/dL cm (Pulungan, et al, 2016).

Sugar-sweetened beverage intake is the average of sugar from packaged and non-packaged beverages. Packaged beverages are processed drinks containing additional sugars recorded on the nutritional fact label on the packaging, whereas non-packaged beverages are sugar-added drinks during brewing and are not recorded on the nutritional fact label on the packaging. Sugar is calculated from the sugar content contained on the package and added sugar during brewing. Measurement of sugar-sweetened beverage intake was obtained by semi quantitative consumption frequency method with frequency question of consumption in a day, week, month, and year and the amount of each time consumption was recorded in household size (URT) and converted to gram. The intake of sugar-sweetened beverage is high if it contains sugar ≥50 g / day and is normal if the sugar content is <50 g / day (Kemenkes, 2013). The energy of sugar sweetened beverage intake is categorized to be high if it is ≥10% of total and normal energy intake if it is <10% of intake total energy (WHO, 2015).Data of energy intake obtained through interviews using Semi Quantitative Food Frequency Questionnaire (SQ-FFQ). Energy requirements were calculated based on individual needs and then the intake data is grouped into the adequacy level based on the National Widyakarya Food and Nutrition (WNPG) 2012), the intake of ≥120% of individual needs is categorized as excess, 90-119% is sufficient, and <90% less. Data were analyzed by Person Product Moment and Rank Spearman correlation test

RESULTS AND DISCUSSIONS

The subjects aged 15-18 years old including 35 (60%) were female subject and 24 (40%) male subject. The results in Table 1 show that the average age of the subjects was 16.2 years and there were subjects with z-score of body mass index for age of 4.9 SD who fall into the obesity category. The intake of sugar-sweetened beverage subjects ranged from 11.8-236.2 g/day with an average sugar-sweetened beverage intake greater than non packaging, i.e. 62.1 g/day and 30.3 g/day. While the mean sugar-sweetened total beverage intake of 92.5 g/day, which means the consumption of sugar-sweetened beverage in the subject tends to be high.

Average triglyceride and fasting blood glucose levels were 113.9 mg/dL and 81.5 mg/dL, respectively, high triglycerides and normal at fasting blood glucose levels.

Table 1. Characteristics of Subjects

	Minimum	Maximum	Mean+DS
Age (years)	15	18	16,2±0,7
Height (cm)	145,0	183,0	160,2±7,4
Weight (kg)	35,9	141,0	63,2±19,1
BMI/age (SD)	-2,7	4,9	0,7±1,5
Intake of SSBs (g/hari)	11,8	236,2	92,5±60,8
SSBs packaging (g/hari)	4,6	198,2	62,1±46,3
SSBs non-packaging (g/hari)	1,7	89,6	30,3±25,2
Energy Intake of SSBs (kkal/hari)	72,4	1516,0	520,5±328,3
Energy Intake of SSBs (% Energi)	3	41,2	19,2±8,7
Energy Intake (kkal/hari)	1171,9	6327,7	2707,2±1037,9
Waist circumference (cm)	56,5	114,7	79,9±12,6
Triglyceride (mg/dL)	96,0	150,0	113,9±10,3
Fasting Blood Glucose Levels (mg/dL)	70,0	98,0	81,5±7,6

Table 2 shows that 72,9% subjects were high intake of SSB, but subjects with sufficient energy intakes were only 28.8%, but 91.5% of subjects took energy from a high sugar-sweetened beverage (> 10% of total energy).

Table 2. Characteristics of *Sugar-Sweetened Beverage* and Energy Intakes

Category of SSB and energy intake	Sex		n (%)
	Male n (%)	Female n (%)	
Sugar Sweetened Beverage (g)			
Sufficient	6 (10,2)	10 (16,9)	16(27,1)
High	18 (30,5)	25 (42,4)	43(72,9)
Energy intake from SSBs (%)			
Sufficient	1 (1,7)	4 (6,8)	5 (8,5)
High	23 (39,0)	31 (52,5)	54 (91,5)
Energy intake (%)			
Less	7 (11,9)	6 (10,2)	13(22,1)
Sufficient	8 (13,5)	9 (15,3)	17(28,8)
High	9 (15,3)	20 (33,9)	29(49,2)

The average total intake of Sugar-sweetened beverage was 92.5g/day, where the packaged sugar-sweetened beverage intake was greater than the non-packed sugar-sweetened beverage, 62.1 g/day and 30.3 g/day. The high intake of sugar-sweetened beverage is in line with energy intake in the subject, where found in 44.1% of subjects who have higher energy intake. The average total sugar-sweetened beverage intake was ± 19.2% of total energy intake. This result is greater than the results of a survey conducted by Centers for Disease Control and Prevention (CDC) in children and adolescents in the United States in 2005-2008, the average intake of sugar from foods and beverages by 16% of total energy intake (Ervin, et al, 2012). The study conducted on adolescents aged 12-14 years old in 2014 (Akhriani, et al 2015) stated that the average sugar consumption in beverages sweetened was 60.43 g (19.04% of total energy). In fact, the suggestion of 50-60% of energy needs obtained from sources of carbohydrates, both complex and simple. However, according to tumpeng a balanced nutritional (TGS), the greatest fulfillment of needs is derived from complex carbohydrate sources, such as whole grains, cereals, various tubers and their processed products.

Whereas simple carbohydrate fulfillment is limited for no more than 50 g/day or <10% of total energy intake (Kemenkes, 2013), (WHO, 2015).

Sugar-sweetened beverage consumption that tends to be high in adolescents is affected by several factors, such as advertisements that are widely broadcasted in the media, the distribution of sugar-sweetened beverage in cafeterias or accessible supermarkets, as well as the influenced by peers. The choice of baverage and eating habits on adolescents is influenced by peer because it is considered as the solidarity of the peers (Robert, 2011), (Flood, et al, 2006). The most commonly consumed type of sugar-sweetened beverage is the type of package beverage, which is tea, milk drinks, fruit drinks, and soft drinks which contribute an average of sugar 20-46 g/packaging as well as non-packaging beverages such as tea and various kinds of ice that has average sugar content of 22-26 g/serving or equivalent to ± 2 tbsp sugar.

Table 3 shows that 14 subjects were classified as obese based on body mass index for age, meanwhile 44.1 % subjects were abdominal obesity, 62.7% of subjects had hypertriglyceride and 44.1% subjects had central obesity.

Table 3. Nutritional status, and component of metabolic syndrome in subjects

Category measurements	Sex		n (%)
	Male n (%)	Female n (%)	
Body mass index for age			
Thin	-	2 (3,4)	2 (3,4)
Normal	13 (22,0)	21 (35,6)	34 (57,6)
Overweight	3 (5,1)	6 (10,2)	9 (15,3)
Obese	8 (13,5)	6 (10,2)	14 (23,7)
Waist circumference (cm)			
Normal (< persentil 80)	15 (25,4)	18 (30,5)	33 (55,9)
Abdominal obesity (≥ persentil 80)	9 (15,3)	17 (28,8)	26 (44,1)
Fasting Blood Glucose Levels (mg/dL)			
Normal (<100 mg/dL)	24 (40,7)	35 (59,3)	59 (100)
Triglyceride (mg/dL)			
Normal (<110 mg/dL)	8 (13,6)	14 (23,7)	22 (37,3)
High (≥110 mg/dL)	16 (27,1)	21 (35,6)	37 (62,7)

The prevalence of obesity in this study was higher than that of the study in 2016, which was 12.8% (Muhammad, Dieny, 2016). The increased of obesity, especially central obesity is closely related to the incidence of metabolic syndrome. Adolescents who fulfill two components of the metabolic syndrome include pre-metabolic syndrome, most of which already occur in the subject, including high waist circumference and high triglyceride levels. Adolescents with pre-metabolic syndrome are at greater risk for becoming metabolic syndrome than with normal adolescents (Widyastuti, et al, 2016). Subjects classified as central obese (≥80th percentile) was 44.1%, with female subjects as (28.8%) was greater than female (15.3%). This result is in accordance with the study of 13-15 year old adolescents in Semarang which stated that the incidence of central obesity in female is greater than male that were 52.6% and 38.6% (Dieny et al, 2015) . This is because female body fat composition is greater than male, ranging from 21-35% as well as women's physical activity tend to be lower than men, so that the excess energy consumed more easily converted into fat and accumulate faster (Piche, et al, 2005)

Central obesity in individuals due to body fat stores and intra-abdominal fat is closely related to metabolic abnormalities and cardiovascular disease (Rodriguez, et al, 2004). Adipose tissue is a tissue that plays an active role in the release of free fat and pro and anti-inflammatory cytokines, so that obese individuals tend to experience cholesterol homeostasis disorders, which one of which was elevated triglyceride levels (Taverne et al 2013). In this study there were subjects with hypertriglyceride of 62.7%. This number is higher than the research in 2016, which is 37.5% (Muhammad, Dieny, 2016).

The increase of components of the metabolic syndrome, one of which is obesity in adolescence occurs due to many factors, one of which is excessive food intake and low physical activity.

The Correlation of Sugar-Sweetened Beverage Intake and energy intake with Metabolic Syndrome Component

Table 4 shows that there was significant correlation between sugar-sweetened beverage intake with waist circumference (p = 0.015) and triglyceride levels (p = 0.044), as well as energy intake (p = 0.014) with triglyceride levels on adolescents. But there was no significant correlation of sugar-sweetened beverage intake with fasting blood glucose levels in adolescents (p = 0.06).

Table 4. Sugar-Sweetened Beverage Intake and energy intake with Waist circumference, Triglyceride Levels, and Fasting Blood Glucose Levels

Variabel	Waist circumference		Triglyceride		Fasting Blood Glucose	
	r	*p*	r	*p*	r	*p*
Intake of *Sugar Sweetened Beverage* (SSBs) (g)	0,302	0,020[a]	0,264	0,044[a]	0,246	0,060[a]
Energi (kkal)	0,208	0,113[b]	0,318	0,014[b]	0,043	0,745[b]

[a] *Rank-Spearman* [b] *Pearson correlation*

This result is in accordance with study conducted on teeangers aged 12-16 in Taiwan who stated that high sugar-sweetened beverage intake associated with an increased component of the metabolic syndrome (Chan, et al, 2014).

Sugar-sweetened beverage can increase waist circumference because the excess energy from sugar-sweetened beverage will be stored in a form of fat inside of body and then it was stored as energy storage in diposa tissue. After that the energy intake from sugar-sweetened beverage is known as liquid form which does not give the effect of full in stomach compare to solid food, therefore will increase excess energy intake. In addition, the fructose content in Sugar-sweetened beverage does not stimulate leptin, hence people who consume high fructose will complain to be hungry faster and eat excessively which will increase the fat accumulation intra abdominal over weight (Pereira, et al 2014), (Shapiro et al, 2008). This is in line with the study conducted to children aged 3-11 years old in England in 2004 and adolescents 12-18 years old in Taiwan in 2014 that high intake of sugar-sweetened beverage can increase Body mass Index (BMI) and waist circumference (Chan, et al , 2014), (Kosova et al, 2014).

The increase of triglyceride levels may occur due to the fructose content present in sugar-sweetened beverage. As much as 60% of the carbohydrates used as sweeteners in sugar-sweetened beverage are fructose that will largely be metabolized in the liver. The first working enzyme is fructokinase or ketoheksokinase

(KHK-C) using adenosine tri phosphate (ATP) to phosphorylate fructose to fructose -1 phosphate. Then the fructose-1 phosphate is converted to dihydroxyacetone phosphate and glyceraldehyde 3-phosphate which is the material to form glycerol 3-phosphate and acetyl-KoA. Furthermore, acetyl-KoA is converted to acyl-KoA which binds to glycerol-3 phosphate to form triacyl glycerol or triglyceride. The cross-sectional study of adolescents in the UK in 2011 suggests that consuming high intake of sugar-sweetened beverage may increase triglyceride levels as well as the risk of cardiovascular disease (Rompay, et al, 2015). A cohort study in children aged 8-15 years also mentions that the intake of sugar-sweetened beverage is positively associated with triglyceride levels (Welsh et al, 2014).

In this study it was showed that no correlation of sugar-sweetened beverage intake with fasting blood glucose levels in adolescents ($p > 0.05$). These results are supported by study conducted on obese adolescets showing no association between intake of sweet beverage with fasting blood glucose levels (Sudono, et al, 2015)

The absence of sugar-sweetened beverage intake link with fasting blood glucose levels in this study because all subjects had fasting blood glucose levels in the normal category, so it cannot give an idea of the relationship of sugar sweetened beverage intake with fasting blood glucose levels. This result is supported by a Brazilian study in 2013 which states that hyperglycemia in adolescents has the smallest percentage, which is 2% (Park et al, 2004). Moreover, fasting blood glucose indicator is more describing if it was conducted on subjects with overweight conditions, has a family history of type 2 diabetes mellitus, and have signs of insulin resistance or conditions associated with insulin resistance (Mittal, 2008). The normal fasting blood glucose levels in adolescents show because the body's compensating system is still good so the body can maintain normal blood glucose levels through the hormone insulin secreted by the pancreas (Buse, et al, 2002). Based on the correlation test, the intake of sugar-sweetened beverage showed a positive correlation with fasting blood glucose, which means higher sugar-sweetened beverage intake then fasting blood glucose level will be higher. This is in line with a cross-sectional study conducted on children and adolescents claiming that sugar intake from beverages can increase fasting blood glucose levels (Wang, 2013), (Perichart, et al, 2010). Sugar-sweetened beverage contains more easily absorbed simple carbohydrates such as sucrose fructose corn syrup (HFCS) on a high-glycemic index diet which would then increase appetite and weight gain associated with the development of glucose intolerance and insulin resistance (Schulze, et al, 2004). In addition, the fructose used as a sweetener in sugar-sweetened beverage also contributes to the failure of glucose tolerance and insulin resistance through the mechanism of de novo lipogenesis (DNL). Fructose induces DNL by providing carbon atoms (glycerol 3 phosphate and acyl-KoA) converted into monoacylglycerol and diacylglycerol (DAG) which were subsequently converted to triglycerides. The accumulation of triglycerides in the liver will result in insulin resistance (Malik, et al, 2010).

CONCLUSIONS

Most of the subjects in this study had a high energy eating habits (49.2%), high fat (71.2%), low fiber (94.9%), and consumed a high sugar beverage (72.9%) and had low physical activity (35.6%). The average sugar intake in drinks reached 92.5 g/day (19.2% of total energy). So that found 44.1% subjects have experienced central obesity and 62.7% have hyper triglyceride which is a component of metabolic syndrome.

RECOMMENDATION

Adolescents need to be educated regarding the limit of consuming sugar sweetened beverage maximum 250 - 350 mL / day or additional sugar to foods and beverage <50 g/day (<4 tbsp/ day) and offset by physical activity for achieving an energy balance and lowering the risk of metabolic syndrome.

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Dear Ms. Fillah Fithra Dieny

Your paper has been Approved.
Thank you.
Best regards,
ISPHE 2018 Committee

Gmail

Fillah Dieny <fillahdieny@gmail.com>

Payment status

ISPHE 2018 <isphe@mail.unnes.ac.id>
Kepada: Fillah Fithra Dieny <fillahdieny@gmail.com>

20 April 2018 pukul 16.02

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