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Sugar-Sweetened Beverage Intake as Risk Factor for Pre-Metabolic Syndrome in Adult Women

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ABSTRACT

This study aimed to analyse the correlation between sugar-sweetened beverage (SSB) intake and pre-metabolic syndrome in adult women. This was a case-control study involving 46 subjects of adult women 40-55 years old in each group. SSB intake and nutrients intake data were obtained through Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) then analysed with NutriSurvey. Statistical analysis done was Chi-Square test. The result showed that case group had an average of waist circumference was 91.9±8.9 cm with a minimum of 80 cm and a maximum of 110 cm. Triglyceride levels in blood had average 166.8±14.4 g/dl with a minimum of 150 g/dl and a maximum of 197 g/dl in case group. The average intake of SSB in pre-metabolic syndrome (case group) was 41.5±1.7 g with minimum and maximum of intake was 12 g and 92.6 g respectively. There was a significant correlation between SSB intake and pre-metabolic syndrome in adult women $p<0.05$ (OR=3.56; 95% CI:1.243-10.170).

Keywords: central obesity, hypertriglycerides, pre-metabolic syndrome, sugar-sweetened beverage

INTRODUCTION

Obesity can occur due to excess of energy which will be converted into fat and stored in adipose tissue (Hall *et al.* 2010; Fair 2005). The prevalence of obesity in adult aged >18 years nationally was 15.4% (MoH 2013). While based on health profile data of Semarang City in 2014 the prevalence of obesity in the population aged ≥15 years in women is 10%, higher than the prevalence in men which only 8% (Semarang Health Department 2014). However, the prevalence maybe was higher in certain female demography as it is found in 2008, the prevalence of obesity in women aged 40-50 years was 55.8% (Trisna & Hamid 2009).

Not all obesity is the same, central obesity is an important indicator for the present of metabolic abnormalities known as metabolic syndrome. Metabolic syndrome may increase the risk of cardiovascular disease and type 2 diabetes mellitus (Lorenzo *et al.* 2007). Central obesity can be determined by waist circumference of ≥ 80 cm (Kamso *et al.* 2011). According to Indonesian Basic Health Research, the prevalence of central obesity increased from 21.7% in 2010 to 26.6% in 2013 (MoH 2013). Based on research conducted in Indonesia, metabolic syndrome indicator often found in adult women aged >30 years, those were central obesity (91.4%), followed by hypertension (84.1%), hypertriglyceridemia (66.0%), low High Density Lipoprotein (HDL) (57.8%), and hyperglycemia (50.2%) (Soewondo *et al.* 2010).

Pre-metabolic syndrome is a collection of two risk factors of metabolic syndrome with mild severity and the most common in adult women is central obesity and hypertriglyceridemia. Based on research conducted in Korea, women aged 30-64 year with pre-metabolic syndrome was found as more prevalent compared to metabolic syndrome in the demography (Choo *et al.* 2016).

As it was mentioned earlier, one of the cause of obesity is excess of energy intake. Energy intake can be obtained from sweet drink or sugar-sweetened beverage (SSB) (Mucci *et al.* 2012; Schwarz *et al.* 2105). SSB is a sugar or sweetener sweetened beverage such as soft-drink, fruit juice, manufactured juice, sweet tea, sugar-added coffee drinks, energy enhancer, and liquid replacement fluid (Cohen *et al.* 2012; Han & Powell 2014).

Research in the United State of America conducted on participants aged 40-59 years showed that SSB intake associated with increased of obesity and risk of cardiovascular disease (Brown *et al.* 2011; Diana *et al.* 2013). Over

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50% of sweeteners added to beverages are fructose rather than glucose (Walker & Goran 2014). Fructose used as a sweetener in food and beverage industry is High-Fructose Corn Syrup (HFCS) (White *et al.* 2015; CDC 2010). Consumption of SSB of more than 1 serving as much as ≥500 ml contributes as much as ±397 kcal/day can meet about 10-25% of the total energy needs in a day (Malik *et al.* 2015). In addition, consumption of fructose sweetener >35 g can decrease the level of leptin hormone, which plays a role in decreasing appetite. Low production of leptin hormone causes one to be easily hungry, so the body needs additional food intake. That causes an increase in excessive energy intake which will be converted into adipose tissue. Increased body fat can contributed the waist circumference, cholesterol level, triglyceride, and LDL which are components of pre-metabolic syndrome (Johnson *et al.* 2009; Srikanthan *et al.* 2016).

Distribution of sweetened drinks in Indonesia, especially in large cities such as Semarang City is wide-spread (Henny & Kartini 2015). A national survey based on Indonesian Basic Health Research in 2013 shows the proportion of consumption of sweet foods/beverages ≥1 times a day for people aged ≥10 years reached 53.1% Nationally and 62% in Central Java (MoH 2013). Research on the relationship SSB intake and pre-metabolic syndrome has never been done in Semarang city where the habit is also prevalent. Thus the study was done to analyze the relationship between SSB intake and pre-metabolic syndrome in adult women in Semarang.

METHODS

Design, location, and time

The research was using case-control study design. The study was conducted from May to July 2017 in Kedungmundu Village, Tembalang Sub-district, Semarang City, Central Java.

Sampling

The study population were women aged 40-55 years in Semarang City, while the subject was drawn from the population of women aged 40-55 years in Kedungmundu Village Semarang. The amount of subject required in this study was 46 in the case and 46 in the control group (Notoatmodjo 2010). Case group were chosen based on screening results of 156 women aged 40-55 years. Screenings were done with questionnaire interviews, waist circumference measurements by trained enumerators, and the blood triglycerides level measured by the Medista Laboratory. Participants who had pre-metabolic syndrome was assigned to the case group and those without pre-metabolic syndrome for the group control. Allocation was done by simple random sampling method. This research recieved certificate of research ethic code issued by Commission of Health Research Ethics FK UNDIP and Dr. Kariadi Semarang No. 546/EC/FK-RSDK/VIII/2017.

Data collection

Measurement of height, weight, waist circumference, and level of triglycerides in the blood were done in screening stage. Height was measured with GEA® microtoise made in Indonesia with 0.1 cm accuracy, weight measured with CAMRY® EB digital scale. 9374 made in China with a precision of 0.1 kg. The waist circumference was measured using meter of Kenko® made in Japan which has a precision of 0.1 cm and blood triglyceride level was measured with hypodermic needle through a blood vessel performed by Medista Laboratory. The inclusion criteria for the case in the study were; women aged 40-55 years, waist circumference of ≥80 cm, trigliserida levels of 150-199 mg/dl. The inclusion criteria for control group were; women aged 40-55 years, waist circumference of <80 cm, trigliserida levels of <150mg/dl. Participants in both of group willing to be the subject of research by filling the informed-consent, not smoking, not menopause yet, not consuming alcohol and drugs which affects the lipid profile, and not in a state of illness or under the care of a physician.

The independent variables in this study was the intake of SSB and the dependent variable was pre-metabolic syndrome. Confounding variables in this study are energy intake, carbohydrate, fat, protein, fiber, and physical activity. The intake of SSB and nutrients is the average daily intake of foods and beverages using added sugars obtained by interviews using the Semi Quantitative-Food Frequency Questionnaire (SQ-FFQ). The analysis of SSB intake is expressed in gram and categorized into adequate intake (<50 g/day) and high intake (≥50 g/day) (Permenkes 2013). Analysis of energy intake such as carbohydrate, fat, and protein were done using Nutrisurvey 2005 applications. After the analysis of the amount of macronutrients in the food comsumed, then compared to the need of each individual using the Mifflin-St. Jeor formula (Mahan 2008). Cut off fiber intake points using RDA 2013 for 40-49 years old as 30 g and 50-55 years of age as much as 28 g. The level of nutrient intake is divided into 2 cate-

gory, excessive (>100% of individual needs) and adequate (≤100% of individual needs). Physical activity variables were obtained by interviews using Long Physical Activity Questionnaire (Long IPAQ) which was a physical activity during the last seven days, covering activities during work, transportation, family care, recreation, and sports. Physical activity levels were categorized under IPAQ Scoring Protocol Long form, where physical activity scores <600 MET-minutes/week (categorized as low physical activity), 600-3000 MET-minutes/week (moderate physical activity), and >3000 MET-minutes/week (high physical activity). Level of triglycerides, obtained by taking blood sample by laboratory workers as much as 1 cc. Before blood sampling, subjects were asked to fast for 10 hours. Levels of triglycerides were measured using spectrophotometric method (GPO-PAP).

Data analysis

Analysis of statistical data using software SPSS 16.0 IBM Company from New York, United States. Univariate data analysis was used to describe the characteristics of the subject by describing each variable including age, weight, body mass index, waist circumference data, food intake data, SSB data, triglyceride level data, and physical activity. Bivariate analysis to see the relationship between SSB and confounder variables with pre-metabolic syndrome using Chi-Square test. Analysis of the closeness of the relationship of two variables using the odds ratio (OR) was performed on the SSB intake variable with the occurrence of pre-metabolic syndrome.

RESULTS AND DISCUSSION

Characteristics of subjects

The total subjects involved up to the end of the study were 92 subjects consisting of 46 subjects in the case group and 46 subjects in the control group. There was no difference in mean of subject's age, energy intake, fat intake, protein intake, fiber intake, and mean score of physical activity between case and control group (Table 1). There is a difference in mean waist circumference, triglycerides, carbohydrate intake, and SSB intake between case and control groups. In the case group, the mean of weight variable, BMI, waist circumference, triglyceride, carbohydrate intake, and SSB intake were higher than control group.

Central obesity is a major trigger of metabolic syndrome (MS) that can lead to the emergence of cardiovascular disease (Trisna & Hamid 2009). Obesity increases the risk of cardiovascular disease by decreasing high density lipoprotein (HDL), increasing fasting plasma triglycerides, low density lipoprotein (LDL), high blood sugar, insulin resistance, and high blood pressure (Trisna & Hamid 2009). Obesity is a condition with abnormal or excessive fat accumulation in adipose tissue. Central obesity is obesity with abdominal fat distribution (abdomen to waist).

Correlation between sugar sweetened beverage intake and confounding variables with pre-metabolic syndrome in adult women

Table 2 shows the relationship between variables with the present of pre-metabolic syn-

Table 1. Characteristics of subjects

Variable	Case			Control			p
	Mean±SD	Min	Max	Mean±SD	Min	Max	
Age (years old)	48.4±3.8	40	55	47.8±3.9	40	55	0.48[a]
Body weight (kg)	65.2±1	47.3	96	54.6±7.4	42.8	73.9	0.01[a]
BMI (kg/m^2)	27.8±3.7	20.7	38	23.8±3	18	29.6	0.01[a]
Waist circumference (cm)	91.9±8.9	80	110	75.5±3.4	66.5	79.9	0.01[b]
Tryglicerides (mg/dl)	166.8±14.4	150	197	105.4±16	56	133	0.01[b]
Energy (kkal)	2,024±4.8	1,115.2	3,349.1	1,981.5±4.3	1,225.1	3,048.7	0.80[b]
Carbohydrate (g)	276.8±6.6	158.9	409.8	248.2±8	143	430.9	0.02[b]
Fat (g)	74.1±3.2	23.8	147.8	82.2±3.5	23.4	156.3	0.21[b]
Protein (g)	72±2.4	33.5	151.1	66.2±2.4	32.5	157.5	0.27[a]
Fiber (g)	14.3±5.2	6.9	32.5	12.7±5.6	3.3	31	0.07[b]
Sugar-sweetened beverage (g)	41.5±1.7	12	92.6	29.1±1.6	4.3	71.5	0.01[b]
Physical activity (MetS)	1,812.1±1	465.5	5,279.5	2,639.1±2.3	155.5	10,815	0.17[b]

[a]Independent T test, [b]Mann-Whitney test

drome in adult women. There was a significant relationship between SSB intake and pre-metabolic syndrome in adult women p<0.05 (OR=3.56; 95% CI:1.243-10.170). This is in line with cohort studies in the United States of adult aged 35 and over 35 who consume SSB of more than 2 serving sizes per day significantly assocaited with increase risk of obesity and cardiovascular disease (p=0.01; RR=1.26) (Hamel *et al.* 2014).

According to the Centers for Disease Control and Prevention (CDC), the definition of SSB is a beverage that is added with a calorie sweetener namely pure white sugar, corn sugar, syrup, honey, and molasses (CDC 2010). The results of the analysis of Semi Quantitative Food Frequency Questionnaire (SQ-FFQ) in this study found that the consumption of SSB, especially in beverages added with pure white sugar and fructose in the case group is higher than the control group. Various research results in the United States on the effects on soft drink beverages containing high calories from sweeteners correlated positively with increased prevalence of obesity in both young and middle aged women (Schwarz *et al.* 2015). The use of fructose as a sweetener in the beverage for 10 weeks on the subject of obese women aged 25-49 years can trigger the emergence of three symptoms of metabolic syndrome, namely dyslipidemia (increased triglycerides, low density lipoprotein/LDL and cholesterol), insulin resistance and visceral fat gain (Teff *et al*. 2009). High consumption of fructose from beverages as much as >30% of the total energy requirement per day for a week causes leptin levels decreased by 44 ng/dl. Leptin affects the work of Neuropeptide-Y (NP-Y) by inhibiting the transmission of synaptic on the Artcuatus nucleus (ARC). The lack of leptin hormone will causes increased appetite and makes the body do not feel full so that the energy intake of food in the body increases. As a result, emerging fat deposits in the body can lead to obesity (Angela *et al.* 2007; Sahu 2011).

Based on the results of research in the United States, the consumption of fructose sweetener in beverages that meet 10-25% of total energy (±40g of sugar) in female subjects aged 18-40 years for 2 weeks can lead to an increase in fasting triglyceride in the blood by 16-21 mg/dl (Stanhope *et al.* 2015). Fructose derived from SSB beverage into the body is absorbed in the small intestine and channeled to the liver via vena porta hepatica to be metabolized. In the liver, fructose

Table 2. Bivariate analysis of energy intake, carbohydrate, fat, protein, fiber, sugar sweetened beverage, and physical activity with pre-metabolic syndrome

Variabels	Case		Control		p	OR (95%CI)
	n	%	n	%		
Intake						
Energy*						
Adequate (%)	21	63.6%	12	36.4%	0.082[a]	2.38(0.990-5.723)
Over	15	46.9%	17	53.1%		
Carbohydrate (%)						
Adequate	29	49.2%	30	50.8%	0.828[a]	0.91(0.388-2.134)
Over	17	51.1%	16	48.5%		
Fats (%)						
Adequate	13	61.9%	8	38.1%	0.320[a]	1.87(0.691-5.069)
Over	33	46.5%	38	53.3%		
Protein (%)						
Adequate	24	52.2%	22	47.8%	0.830[a]	1.19(0.525-2.697)
Over	22	47.8%	24	52.2%		
Fiber (%)						
Deficient	44	50.0%	44	50.0%	1[a]	1.00(0.135-7.419)
Adequate	2	50.0%	2	50.0%		
Sugar sweetened beverage (g)						
Adequate	30	42.9%	40	57.1%	0.018[a]	3.56(1.243-10.170)
Over	16	72.7%	6	27.3%		
Physical activity (METs)						
Light	4	57.1%	3	42.9%	0.816[a]	-
Moderate	35	50.7%	34	49.3%		
Severe	7	43.8%	9	56.2%		

OR:Odds Ratio; CI: Confidance Interval; [a]Chi-Square test

undergoes glycolysis into fructose 1-phosphate in a process that is faster than glucose because it passes by the catalyst of phosphofructokinase enzyme. Fructose1-phosphate is then broken down into glyceraldehyde by aldolase. Glyceraldehyde is dehydrogenated to glycerol which is aided by glycerol dehydrogenase enzyme. The glycerol formed is phosphorylated (addition of phosphate group) by glycerolyzing enzyme into glycerol 3-phosphate. Three carbon atoms of glycerol 3-phosphate are converted into glucose by gluconeogenesis resulting in increased synthesis of glycerol, fatty acid, fatty acid esterification and VLDL secretion that can form triglycerides. In the end, high fructose intake can produce large amounts of triglyceride synthesis, causing hypertriglycerides (Lin *et al.* 2013; Teff *et al.* 2009).

CONCLUSION

Participants whose intake of SSB was ≥50 g/day were at risk of pre-metabolic syndrome (central obesity and hypertriglyceride). The pre-metabolic syndrome cases group had higher average of SSB intake compared with the control group. Average SSB intake in case group was 41.5 g with a minimum consumption of 12 g and a maximum of 92.6 g. A cohort study is suggested to follow the participants over a certain period of time to establish stronger justification for causal relationship in the association of SSB intake as a risk factor for pre-metabolic syndrome.

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