Jurnal Gizi Indonesia (The Indonesian Journal of Nutrition)
Jurnal Gizi Indonesia (The Indonesian Journal of Nutrition)
Vol. 12, No. 1, December 2023 (21-30)
Submitted: 10 October, Accepted: 27 November2023
Online https://ejournal.undip.ac.id/index.php/jgi

Association of food consumption and physical activity with metabolic syndrome according to central obesity status in Indonesian adults: A cross-sectional study

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ABSTRACT

Background: Previous studies have reported that the risk of metabolic syndrome differs between obese and non-obese individuals based on food consumption and physical activity.

Objective: This study aims to analyze differences in the association of food consumption and physical activity with the incidence of metabolic syndrome in individuals with and without central obesity.

Materials and Methods: This cross-sectional study examined individuals aged 19 to 64 years using Riskesdas 2018 data. Sample characteristics, including smoking habits, alcohol consumption, food consumption, physical activity, anthropometric data, clinical data, and biochemical data were collected for univariate, bivariate, and multivariate analyses. Logistic regression was used as a multivariate analysis to investigate the association of food consumption and physical activity with the risk of metabolic syndrome in individuals with and without central obesity.

Results: In this study, individuals with and without central obesity significantly increased risk of metabolic syndrome ($p<0.05$) due to consuming nearly all kinds of unhealthy foods (sweet foods, savory foods, fatty/cholesterol-rich/fried foods, grilled foods, processed meat/chicken/fish, soft drinks/carbonated drinks, energy drinks, and instant noodles/other instant foods). However, only individuals without central obesity who frequently consume seasonings (OR=1.519, 95% CI: 1.241-1.859) have a significant association with an increased risk of metabolic syndrome. Meanwhile, only individuals with central obesity who often consume sugary drinks (OR=1.315, 95% CI: 1.132-1.529) are significantly associated with an increased risk of metabolic syndrome. In addition, inadequate consumption of fruits and vegetables as well as lack of physical activity also significantly increase the risk of metabolic syndrome in individuals with and without central obesity ($p<0.05$).

Conclusion: Only the consumption of seasonings and sugary drinks shows a different relationship to the risk of metabolic syndrome in individuals with and without central obesity.

Keywords: *central obesity; food consumption; metabolic syndrome; physical activity*

BACKGROUND

As a serious global health problem, the global prevalence of central obesity reaches 41.5%.[1] The prevalence of central obesity is also high in some countries, such as southern China (10.2%),[2] southwestern Iran (28.6%),[3] and north-eastern Ethiopia (16.5%).[4] In Indonesia, the prevalence of central obesity also increased by 4.4% between 2013 and 2018.[5,6] The increase in cases of central obesity is influenced by several factors, including age, gender, place of residence,[2] education level, Body Mass Index (BMI), smoking habit, alcohol consumption,[7] food consumption,[8–11] and physical activity.[12]

Central obesity-induced metabolic syndrome risk,[13] a group of risk factors, i.e., increased waist circumference, blood glucose level, triglycerides level, and blood pressure, as well as decreased HDL level, which has a close relation to cardiometabolic diseases.[14] Increases in visceral adipose tissue volume and waist circumference reduce insulin sensitivity,[15] which eventually lead to an increased risk of metabolic syndrome in individuals with central obesity.[13]

Several factors, such as food consumption and physical activity, affect the incidence of metabolic syndrome in individuals with central obesity. The incidence of metabolic syndrome is more common in individuals with central obesity who often consume unhealthy foods and rarely consume fruits and vegetables compared to individuals with central obesity who rarely consume unhealthy foods and often consume fruits and vegetables.[15–21] Furthermore, individuals with central obesity who undertake low-intensity physical activity are more likely to develop metabolic syndrome compared to individuals with central obesity who engage in higher-intensity physical activity.[17,22,23] Not only individuals with central obesity but also individuals without central obesity have metabolic syndrome. In this regard, individuals without central obesity who consume large amounts of unhealthy foods and do not engage in physical

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activity may have an increased risk of metabolic syndrome compared to individuals without central obesity who consume less unhealthy food and do physical activity.[24–26]

However, previous studies have not analyzed whether there a differences or similarities in association between food consumption and physical activity on the incidence of metabolic syndrome in individuals with and without central obesity. Leite et al. (2009) and Suliga et al. (2018) explained that the risk of metabolic syndrome differs between obese individuals and those with normal weight based on food consumption and physical activity.[27,28] Individuals with central obesity and without central obesity may differ in their risk of metabolic syndrome based on food consumption and physical activity levels. Therefore, we aimed to analyze the differences in the association of food consumption and physical activity with metabolic syndrome risk in individuals with and without central obesity in Indonesia.

MATERIALS AND METHODS

This cross-sectional study employed Riset Kesehatan Dasar (Riskesdas) data in 2018 The Riskesdas survey covered all households in Indonesia using a stratified sampling method. The sample interviewed are a sample of selected households. Furthermore, the sample for the biochemical measurements is a sub-sample that represents the selected population from 26 provinces.[6] In this study, the selected samples from the Riskesdas data were filtered using a consecutive sampling method. Individuals aged 19-64 years with anthropometric, clinical, and biochemical measurements were included in this study. Meanwhile, the exclusion criteria were missing and extreme data. The sample size of this study was 14,302. This study has been approved by Badan Kebijakan Pembangunan Kesehatan Kementerian Kesehatan Republik Indonesia No. IR.03.01/8/300/2023.

Riskesdas collected data on sample characteristics (age, gender, education level, and place of residence), alcohol consumption, and smoking habit through interviews using a standardized questionnaire[6]. Meanwhile, data regarding consumption of unhealthy foods (sweet foods, sugary drinks, savory foods, fatty/cholesterol-rich/fried foods, grilled foods, processed meat/chicken/fish, seasonings, soft drinks/carbonated drinks, energy drinks, and instant noodles/other instant foods), fruits, and vegetables were obtained through interviews using questionnaires and food image models. The frequency of unhealthy food consumption was classified into often (≥1 time per day or 1-6 times per week) and rare (≤3 times per month or never), whereas the consumption of fruits and vegetables was considered adequate if individuals consumed ≥5 servings of fruits and vegetables per day. Furthermore, data on physical activity were acquired from interviews using the GPAC questionnaire and physical activity models. Physical activity was categorized as sufficient if moderate and vigorous physical activity was done for ≥150 minutes/week.

The anthropometric data used this study cover body weight, height, and waist circumference. Body weight was measured using a body weight scale, while height was measured with a stadiometer. Measurements of body weight and height were used to calculate the Body Mass Index (BMI). Furthermore, waist circumference was measured with a measuring tape to determine central obesity and metabolic syndrome. Blood pressure was measured using a tensimeter, while blood glucose data (fasting blood glucose and postprandial blood glucose level) were obtained via capillary blood sampling and measured by Accuchek Performa. Lastly, blood lipid biochemical data (cholesterol, LDL, HDL, and triglyceride level) were gained through venous blood sampling and analyzed with a chemical autoanalyzer.[6]

In this study, waist circumference, blood pressure, and biochemical data (including fasting blood glucose, triglycerides, and HDL level) were used to determine metabolic syndrome status. An individual was considered to have metabolic syndrome if there were at least 3 of the following 5 risk factors: increase in waist circumference >90 cm in males and >80 cm in females, increase in triglyceride level ≥150 mg/dL, decrease in HDL level <40 mg/dL in males and <50 mg/dL in females, increase in systolic blood pressure ≥130 and/or diastolic blood pressure ≥85 mmHg, and increase in fasting blood glucose level ≥100 mg/dL.14

The data collected by Riskesdas were analyzed using Microsoft Excel and SPSS 25 software with a significance level of a *p*-value ≤0.05. Univariate analysis was performed to determine the distribution of values for each variable. Meanwhile, bivariate analyses were carried out to examine the association between sample characteristics and central obesity using the chi-square test (for categorical variables) and t-test (for numerical variables). The chi-square test was also done to find the association between independent variables (food consumption and physical activity) and metabolic syndrome according to central obesity status. Furthermore, the multivariate analysis used logistic regression to investigate the association of food consumption and physical activity with the risk of metabolic syndrome in individuals with and without central obesity. Logistic regression analysis was performed to control confounding variables, such as age, gender, education level, place of residence, alcohol consumption, smoking habit, Body Mass Index (BMI), cholesterol level, and Low Density Lipoprotein (LDL) level.

RESULTS

The mean age of individuals with central obesity is 44.74 ± 10.71 years. In this study, central obesity is found to be more prevalent in females (82.3%), individuals living in urban areas (53.7%), individuals with low education level (71%), non-alcohol drinkers (99.3%), and non-smokers (84.7%). Most individuals with central obesity are overweight (80.8%) and have high blood pressure (systolic: 59.1%; diastolic: 63.7%), normal fasting blood glucose level (55%), high postprandial blood glucose level (54.7%), normal cholesterol level (59.7%), high LDL level (50.9%), normal triglycerides level (63.8%), and low HDL level (58.6%). The prevalence of metabolic syndrome in individuals with central obesity is 72.2%.

Table 1. Sample Characteristics

Variable	Central Obesity		Non Central Obesity		*p*	Sample Size	
	n=6,913	Mean±SD	n=7,389	Mean±SD		n =14,302	Mean±SD
Age (years)		44.74±10.7		43.51±12.4			44.11±11.7
Gender							
Male, n(%)	1,224 (17.7%)		4,021 (54.4%)		0.000*	5,245 (36.7%)	
Female, n(%)	5,689 (82.3%)		3,368 (45.6%)			9,057 (63.3%)	
Education Level							
High, n(%)	2,004 (29%)		1,929 (26.1%)		0.000*	3,933 (27.5%)	
Low, n(%)	4,909 (71%)		5,460 (73.9%)			10,369 (72.5%)	
Place of Residence							
Rural, n(%)	3,198 (46.3%)		5,042 (68.2%)		0.000*	8,240 (57.6%)	
Urban, n(%)	3,715 (53.7%)		2,347 (31.8%)			6,062 (42.4%)	
Alcohol Consumption							
No, n(%)	6,865 (99.3%)		7,271 (98.4%)		0.000*	14,136 (98.8%)	
Yes, n(%)	48 (0.7%)		118 (1.6%)			166 (1.2%)	
Smoking Habit							
No, n(%)	5,856 (84.7%)		4,138 (56%)		0.000*	9,994 (69.9%)	
Yes, n(%)	1,057 (15.3%)		3,251 (44%)			4,308 (30.1%)	
Body Mass Index (kg/m^2)		28.37±4.14		21.86±3.13			25.01±4.89
Underweight, n(%)	11 (0.2%)		889 (12%)		0.000*	900 (6.3%)	
Normal, n(%)	1,316 (19%)		5,436 (73.6%)			6,752 (47.2%)	
Overweight, n(%)	5,586 (80.8%)		1,064 (14.4%)			6,650 (46.5%)	
Systolic Blood Pressure (mmHg)		139.4 ± 24.7		129.8±22.3			134.4±23.9
Normal, n(%)	2,826 (40.9%)		4,401 (59.6%)		0.000*	7,227 (50.5%)	
High, n(%)	4.087 (59.1%)		2,988 (40.4%)			7,075 (49.5%)	
Diastolic Blood Pressure (mmHg)		89.9±13.1		82.4±12.2			86.08±13.2
Normal, n(%)	2,511 (36.3%)		4,575 (61.9%)		0.000*	7,086 (49.5%)	
High, n(%)	4,402 (63.7%)		2,814 (38.1%)			7,216 (50.5%)	
Fasting Blood Glucose Level (mg/dL)		108.9±39.4		101.4±30.6			105±35.3
Normal, n(%)	3,804 (55%)		4,829 (65.4%)		0.000*	8,633 (60.4%)	
High, n(%)	3,109 (45%)		2,560 (34.6%)			5,669 (39.6%)	

Table 1. Sample Characteristics (Continue…)

Variable	Central Obesity		Non Central Obesity		p	Sample Size	
	n=6,913	Mean±SD	n=7,389	Mean±SD		n=14,302	Mean±SD
Postprandial Blood Glucose Level (mg/dL)		159.4±60.2		142.9±52.5			150.9±56.9
Normal, n(%)	3,129 (45.3%)		4,394 (59.5%)		0.000*	7,523 (52.6%)	
High, n(%)	3,784 (54.7%)		2,995 (40.5%)			6,779 (47.4%)	
Cholesterol Level (mg/dL)		194.3±41.1		178±37.9			185.9±40.3
Normal, n(%)	4,128 (59.7%)		5,550 (75.1%)		0.000*	9,678 (67.7%)	
High, n(%)	2,785 (40.3%)		1,839 (24.9%)			4,624 (32.3%)	
Low-Density Lipoprotein (LDL) Level (mg/dL)		133.1±35.3		118.6±31.9			125.6±34.4
Normal, n(%)	3,391 (49.1%)		5,032 (68.1%)		0.000*	8,423 (58.9%)	
High, n(%)	3,522 (50.9%)		2,357 (31.9%)			5,879 (41.1%)	
High-Density Lipoprotein (HDL) Level (mg/dL)		48.37±11.6		46.53±10.3			47.48±11.1
Normal, n(%)	2,862 (41.4%)		4,627 (62.6%)		0.000*	7,489 (52.4%)	
Low, n(%)	4,051 (58.6%)		2,762 (37.4%)			6,813 (47.6%)	
Triglyceride Level (mg/dL)		145.1±105.4		120.3±87.1			132.3±97.2
Normal, n(%)	4,411 (63.8%)		5,678 (76.8%)		0.000*	10,089 (70.5%)	
High, n(%)	2,502 (36.2%)		1,711 (23.2%)			4,213 (29.5%)	
Metabolic Syndrome							
No, n(%)	1,923 (27.8%)		5,844 (79.1%)		0.000*	7,767 (54.3%)	
Yes, n(%)	4,990 (72.2%)		1,545 (20.9%)			6,535 (45.7%)	

The *p*-value was obtained from the chi-square[1] test (for categorical variables) and t-test[2] (for numerical variables). *significant (p<0.05)

Table 2 shows the prevalence of food consumption and physical activity according to central obesity status and metabolic syndrome. Individuals with central obesity who often consume fatty/cholesterol-rich/fried foods (88.6%) and seasonings (92.1%) are more likely to have metabolic syndrome than individuals without central obesity. Conversely, individuals without central obesity who often consume sugary drinks (86%), savory foods (75.9%), soft drinks/carbonated drinks (9.3%), and energy drinks (6.7%) are more likely to have metabolic syndrome than individuals with central obesity.

The results of the logistic regression analyses on the risk of metabolic syndrome in individuals with and without central obesity before and after controlling for confounding variables (age, gender, education level, place of residence, alcohol consumption, smoking habit, Body Mass Index, and postprandial glucose, cholesterol, and LDL level) are presented in Tables 3 and 4, respectively. Individuals with central obesity who often consume sweet foods (OR=1.272, 95%CI: 1.101-1.468), sugary drinks (OR=1.315, 95%CI: 1.132-1.529), savory foods (OR=1.397, 95%CI: 1.234-1.581), fatty/cholesterol-rich/fried foods (OR=1.270, 95%CI: 1.082-1.492), grilled food (OR=1.276, 95%CI: 1.118-1.475), processed meat/fish/chicken (OR=1.440, 95% CI: 1.238-1.674), soft drinks/carbonated drinks (OR=1.814, 95%CI: 1.360-2.420), energy drinks (OR=1.901, 95% CI: 1.266-2.854), and instant noodles/other instant foods (OR=1.330, 95% CI: 1.183-1.495) are significantly associated with an increased risk of metabolic syndrome after controlling for confounding variables. In addition, inadequate consumption of fruits and vegetables (OR=1.371, 95% CI: 1.014-1.853) and lack of physical activity (OR=1.163, 95% CI: 1.012-1.336) in individuals with central obesity have a significant association with an increased risk of metabolic syndrome after controlling for confounding variables.

Table 2. Prevalence of Food Consumption and Physical Activity According to Central Obesity Status and Metabolic Syndrome

Variable	Metabolic Syndrome			
	Central Obesity	Non Central Obesity	*p*	Sample Size
	n = 4,990	n = 1,545		n = 6,535
Sweet Foods				
Rare (n (%))	959 (19.2%)	297 (19.2%)	1.00	1,256 (19.2%)
Often (n (%))	4,031 (80.8%)	1,248 (80.8%)		5,279 (80.8%)
Sugary Drinks				
Rare (n (%))	806 (16.2%)	217 (14%)	0.05*	1,023 (15.7%)
Often (n (%))	4,184 (83.8%)	1,328 (86%)		5,512 (84.3%)
Savory Foods				
Rare (n (%))	1,347 (27%)	372 (24.1%)	0.03*	1,719 (26.3%)
Often (n (%))	3,643 (73%)	1,173 (75.9%)		4,816 (73.7%)
Fatty/Cholesterol-rich/Fried Foods				
Rare (n (%))	570 (11.4%)	213 (13.8%)	0.01*	783 (12%)
Often (n (%))	4,420 (88.6%)	1,332 (86.2%)		5752 (88%)
Grilled Foods				
Rare (n (%))	3,495 (70%)	1,055 (68.3%)	0.20	4,550 (69.6%)
Often (n (%))	1,495 (30%)	490 (31.7%)		1,985 (30.4%)
Processed Meat/Chicken/Fish				
Rare (n (%))	3,869 (77.5%)	1,217 (78.8%)	0.32	5,086 (77.8%)
Often (n (%))	1,121 (22.5%)	328 (21.2%)		1,449 (22.2%)
Seasonings				
Rare (n (%))	395 (7.9%)	147 (9.5%)	0.05*	542 (8.3%)
Often (n (%))	4,595 (92.1%)	1,398 (90.5%)		5,993 (91.7%)
Soft Drinks/Carbonated Drinks				
Rare (n (%))	4,609 (92.4%)	1,402 (90.7%)	0.05*	6,011 (92%)
Often (n (%))	381 (7.6%)	143 (9.3%)		524 (8%)
Energy Drinks				
Rare (n (%))	4,777 (95.7%)	1,442 (93.3%)	0.00*	6,219 (95.2%)
Often (n (%))	213 (4.3%)	103 (6.7%)		316 (4.8%)
Instant Noodles/Other Instant Foods				
Rare (n (%))	2,130 (42.7%)	617 (39.9%)	0.06	2,747 (42%)
Often (n (%))	2,860 (57.3%)	928 (60.1%)		3,788 (58%)
Fruit and Vegetable Consumption				
Adequate (n (%))	143 (2.9%)	47 (3%)	0.78	190 (2.9%)
Inadequate (n (%))	4,847 (97.1%)	1,498 (97%)		6,345 (97.1%)
Physical Activity				
Adequate (n (%))	3,827 (76.7%)	1,185 (76.7%)	1.00	5,012 (76.7%)
Inadequate (n (%))	1,163 (23.3%)	360 (23.3%)		1,523 (23.3%)

The *p*-value was obtained from the chi-square test. *significant ($p<0.05$).

As seen in Table 4, individuals without central obesity who often consume sweet foods (OR=1.426, 95%CI: 1.218-1.669), savory foods (OR=1.193, 95%CI: 1.035-1.374), fatty/cholesterol-rich/fried food (OR=1.398, 95%CI: 1.178-1.659), grilled foods (OR=1.197, 95%CI: 1.044-1.374), processed meat/fish/chicken (OR=1.614, 95%CI: 1.374-1.896), seasoning (OR=1.519, 95%CI: 1.241-1.859), soft drinks/carbonated drinks (OR=1.670, 95%CI: 1.310-2.129), energy drinks (OR=1.527, 95%CI: 1.158-2.012), and instant noodles/other instant foods (OR=1.746, 95%CI: 1.542-1.978) were significantly associated with an increased risk of metabolic syndrome after controlling for confounding variables. Furthermore, inadequate consumption of fruit and vegetable (OR=2.144, 95%CI: 1.538-2.988) and lack of physical activity (OR=1,295, 95%CI: 1.117-1,502) also had a significant correlation with an increased risk of metabolic syndrome in individuals without central obesity after controlling for confounding variables.

Table 3. Risk Analysis of Metabolic Syndrome Based on Food Consumption and Physical Activity in Individuals with Central Obesity

Variable	Model 1[a]			Model 2[b]		
	OR	95%CI	*p*	OR	95%CI	*p*
Sweet Foods						
Rare	ref			ref		
Often	1.183	1.031-1.357	0.017*	1.272	1.101-1.468	0.001*
Sugary Drinks						
Rare	ref			ref		
Often	1.235	1.070-1.426	0.004*	1.315	1.132-1.529	0.000*
Savory Foods						
Rare	ref			ref		
Often	1.313	1.166-1.478	0.000*	1.397	1.234-1.581	0.000*
Fatty/Cholesterol-Rich/Fried Foods						
Rare	ref			ref		
Often	1.337	1.146-1.560	0.000*	1.270	1.082-1.492	0.003*
Grilled Foods						
Rare	ref			ref		
Often	1.254	1.104-1.423	0.000*	1. 276	1.118-1.475	0.000*
Processed Meat/Chicken/Fish						
Rare	ref			ref		
Often	1.342	1.161-1.551	0.000*	1.440	1.238-1.674	0.000*
Seasonings						
Rare	ref			ref		
Often	1.090	0.903-1.316	0.370	1.096	0.900-1.333	0.362
Soft Drinks/Carbonated Drinks						
Rare	ref			ref		
Often	1.677	1.268-2.218	0.000*	1.814	1.360-2.420	0.000*
Energy Drinks						
Rare	ref			ref		
Often	1.907	1.282-2.837	0.001*	1.901	1.266-2.854	0.002*
Instant Noodles/Other Instant Foods						
Rare	ref			ref		
Often	1.195	1.071-1.335	0.002*	1.330	1.183-1.495	0.000*
Fruit and Vegetable Consumption						
Adequate	ref			ref		
Inadequate	1.377	1.031-1.841	0.030*	1.371	1.014-1.853	0.040*
Physical Activity						
Adequate	ref			ref		
Inadequate	1.215	1.065-1.386	0.004*	1.163	1.012-1.336	0.033*

Reference group: consumption of unhealthy foods: rarely; fruit and vegetable consumption and physical activity: adequate
[a]Unadjusted; [b]Confounding variables: age, gender, place of residence, education level, Body Mass Index, smoking habit, alcohol consumption, postprandial blood glucose level, cholesterol level, and LDL level. *significant (p<0.05).

Table 4. Risk Analysis of Metabolic Syndrome Based on Food Consumption and Physical Activity in Individuals without Central Obesity

Variable	Model 1[a]			Model 2[b]		
	OR	95%CI	*p*	OR	95%CI	*p*
Sweet Foods						
Rare	ref			ref		
Often	1.332	1.146-1.548	0.000*	1.426	1.218-1.669	0.000*
Sugary Drinks						
Rare	ref			ref		
Often	1.010	0.852-1.198	0.904	1.117	0.932-1.338	0.230
Savory Foods						
Rare	ref			ref		
Often	1.204	1.052-1.378	0.007*	1.193	1.035-1.374	0.015*
Fatty/Cholesterol-Rich/Fried Foods						
Rare	ref			ref		
Often	1.284	1.090-1.511	0.003*	1.398	1.178-1.659	0.000*
Grilled Foods						
Rare	ref			ref		
Often	1.189	1.044-1.353	0.009*	1.197	1.044-1.374	0.010*
Processed Meat/Chicken/Fish						
Rare	ref			ref		
Often	1.600	1.377-1.860	0.000*	1.614	1.374-1.896	0.000*

Table 4. Risk Analysis of Metabolic Syndrome Based on Food Consumption and Physical Activity in Individuals without Central Obesity (Continue…)

Variable	Model 1[a]			Model 2[b]		
	OR	95%CI	*p**	OR	95%CI	*p**
Seasonings						
Rare	ref			ref		
Often	1.382	1.141-1.674	0.001*	1.519	1.241-1.859	0.000*
Soft Drinks/Carbonated Drinks						
Rare	ref			ref		
Often	1.678	1.342-2.099	0.000*	1.670	1.310-2.129	0.000*
Energy Drinks						
Rare	ref			ref		
Often	1.307	1.013-1.688	0.040*	1.527	1.158-2.012	0.003*
Instant Noodles/Other Instant Food						
Rare	ref			ref		
Often	1.522	1.355-1.711	0.000*	1.746	1.542-1.978	0.000*
Fruit and Vegetable Consumption						
Adequate	ref			ref		
Inadequate	1.997	1.450-2.750	0.000*	2.144	1.538-2.988	0.000*
Physical Activity						
Adequate	ref			ref		
Inadequate	1.298	1.131-1.491	0.000*	1.295	1.117-1.502	0.001*

Reference group: consumption of unhealthy foods: rarely; fruit and vegetable consumption and physical activity: adequate
[a]Unadjusted; [b]Confounding variables: age, gender, place of residence, education level, Body Mass Index, smoking habit, alcohol consumption, postprandial blood glucose level, cholesterol level, and LDL level. *significant (p<0.05).

DISCUSSION

The prevalence of metabolic syndrome is higher in individuals with central obesity. Individuals with central obesity have increased visceral adipose tissue volume and waist circumference,[13] Increased visceral adipose tissue volume and waist circumference decrease insulin sensitivity, which triggers the risk of metabolic syndrome.[15,16,29,30] Individuals with and without central obesity who frequently consume almost all unhealthy foods (sweet foods, savory foods, fatty/cholesterol-rich/fried foods, grilled foods, processed meat/chicken/fish, soft drinks/carbonated drinks, energy drinks, and instant noodles/other instant foods) are at a higher risk of metabolic syndrome. Unhealthy foods are generally energy dense and high in sodium which can reduce insulin sensitivity Individuals with central obesity and without central obesity who have decreased insulin sensitivity resulting in an increased risk of metabolic syndrome.[15,16,35,20,21,29–34]

This study also shows that there is a difference in the association of unhealthy food consumption with the risk of metabolic syndrome in individuals with and without central obesity. In individuals with central obesity, the consumption of seasonings does not increase the risk of metabolic syndrome. In contrary, individuals without central obesity who frequently consume seasonings have an increased risk of metabolic syndrome. This is because the consumption of seasonings may reduce insulin sensitivity in individuals without central obesity,[36] but not in individuals with central obesity.[37,38] Individuals with central obesity who do not have decreased insulin sensitivity may lower risk of metabolic syndrome, whereas individuals without central obesity who have decreased insulin sensitivity may have an increased risk of metabolic syndrome.[15]

The association between the consumption of sugary drinks and the risk of metabolic syndrome also differs in individuals with and without central obesity. In individuals with central obesity, frequent consumption of sugary drinks may increase the risk of metabolic syndrome. On the other hand, individuals without central obesity who often consume sugary drinks do not have an increased risk of metabolic syndrome. Individuals with central obesity had an increase in waist circumference, which is associated with decreased insulin sensitivity that increases the risk of metabolic syndrome. Meanwhile, individuals without central obesity do not have an increased waist circumference,[39] which is related to improved insulin sensitivity, thus resulting in a lower risk of metabolic syndrome.[15,30]

Fruits and vegetables are high-fiber foods,[40] while low fiber may increase metabolic syndrome risk.[15,41] Therefore, individuals with and without central obesity who consume less fruits and vegetables are at a greater risk of metabolic syndrome. In addition, individuals with and without central obesity who lack physical activity also have an increased risk of metabolic syndrome. Lack of physical activity decreases insulin sensitivity,[26] which can increase the risk of metabolic syndrome.[15]

e-ISSN : 2338-3119, p-ISSN: 1858-4942

CONCLUSION

Individuals with and without central obesity who frequently consume almost all unhealthy foods (sweet foods, savory foods, fatty/cholesterol-rich/fried foods, grilled foods, processed meat/chicken/fish, soft drinks/carbonated drinks, energy drinks, and instant noodles/other instant foods) are significantly related to an increased risk of metabolic syndrome. Meanwhile, in terms of frequent consumption of seasonings, only individuals without central obesity are significantly correlated with an increased risk of metabolic syndrome. Furthermore, only individuals with central obesity who often consume sugary drinks have a significant correlation with an increased risk of metabolic syndrome. In individuals with and without central obesity, inadequate consumption of fruits and vegetables and lack of physical activity are significantly associated with an increased risk of metabolic syndrome. Therefore, future studies are highly recommended to include analysis of dietary patterns using an a priori or posteriori approach as well as examination on food consumption that includes nutritional values.

ACKNOWLEDGMENT

We thank to Research Development and Community Service Unit (UP3), Faculty of Medicine, Diponegoro University for supporting this research (2/UN7.F4/HK/VII/2023).

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