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Micronutrient intake and sedentary lifestyle based on metabolic type in female college students with normal weight

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Abstract

Individuals with a body mass index (BMI) within the normal range are considered healthier. However, according to a study, several individuals with a BMI of <25 kg/m^2 also showed an increased risk of developing metabolic disorders. Abnormal metabolism is influenced by several factors, including micronutrient intake and a sedentary lifestyle. This study aimed to analyze differences in micronutrient intake, such as calcium, vitamin D, vitamin E, vitamin C, and sedentary lifestyle in metabolically unhealthy normal weight (MUNW) and metabolically healthy normal weight (MHNW) individuals. This investigation was an observational research study with a case-control design. Sampling was performed using consecutive sampling with 25 subjects for each group. All subjects were female with an age range of 19-23 years. Subjects had BMI screening and blood sampling. Micronutrient intake was measured by the Semi-Quantitative–Food Frequency Questionnaire (SQFFQ) and sedentary lifestyle using the Adolescent Sedentary Activity Questionnaire (ASAQ). Bivariate analysis was performed using the independent t-test and the Mann–Whitney U test. The intake of calcium, vitamin D, E, and C in MHNW was higher than in MUNW and was significantly different except for vitamin D, although the two groups' mean adequacy level was still classified as a deficit. The MUNW's duration of sedentary activity (703.4 mins/day) was higher than the MHNW's (515.8 mins/day), and the mean of the two groups was classified as high. There were differences in the intake of calcium, vitamins C and E, and a sedentary lifestyle between the MHNW and MUNW groups ($p<0.05$). Intakes of micronutrients such as calcium, vitamin C, and vitamin E in the MHNW group were higher than that in the MUNW group. It differed significantly, although the level of adequacy in both groups was classified as a deficit rather than a requirement.

1. Introduction

Today, the prevalence of obesity and being overweight has increased globally over the last few decades. Based on the National Basic Health Research (Riskesdas) 2018, the prevalence of obesity in adults aged >18 years increased from 14.8% in 2013 to 21.8% in 2018 (Kemenkes RI, 2018). This health problem is considered to increase morbidity and mortality. Individuals with a body mass index (BMI) within the normal range are considered healthier and have protective factors in reducing premature mortality risk (Stefan *et al*., 2017). However, according to a study, some individuals with a BMI of less than 25 kg/m^2 also show an increased risk of developing metabolic disorders commonly associated with obese individuals, such as abdominal obesity and increased blood pressure (Mathew *et al*., 2017). Metabolic disorders occur when two or more criteria are met, such as blood pressure ≥130/85 mmHg, triglyceride levels ≥150 mg/dL, high-density lipoprotein (HDL) cholesterol <40 mg/dL in men and <50 mg/dL in women, fasting blood glucose ≥100 mg/dL, high sensitivity C-reactive protein level >90th percentile, and insulin resistance (Stefan *et al*., 2017). A review of the NHANES data from 1999 to 2004 using two or more criteria for metabolic disorders revealed that 23.5% of adults with normal weight have an abnormal metabolism, also known as metabolically unhealthy normal weight (MUNW) (Wildman *et al*., 2015).

Several factors, including gender, race/ethnicity, genetics, lifestyle changes, physical activity, smoking, alcohol consumption, and diet, are influenced by

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abnormal metabolism (Grundy *et al*., 2005). A study stated that switching from saturated fatty acids to MUFA and PUFA is also associated with decreased metabolic syndrome (Julibert *et al*., 2019). However, current research on metabolic syndrome has started linking it with the functions of certain micronutrients such as calcium, vitamin D, vitamin E, and vitamin C. Micronutrients in the body play an important role in structural support and biological functions. A study indicated that men of normal weight with high blood pressure decreased HDL cholesterol levels, and metabolic syndrome experience weight loss when they increase their calcium intake (Shin *et al*., 2016). In addition, other studies have shown that higher calcium consumption in the adult population for five years reduces the case of increased body weight and waist circumference (Samara *et al*., 2013). This result may be related to the ability of calcium to regulate energy metabolism.

A study showed that subjects with vitamin D deficiency are at three to six times higher risk of developing hypertension over four years than subjects with optimal vitamin D status (Prasad and Kochhar, 2015). Vitamin D deficiency is associated with increased arterial stiffness and endothelial dysfunction. Vitamin E is anti-hyperlipidemic and anti-inflammatory when tested in animals (Wong *et al*., 2017). Meanwhile, vitamin C is associated with the incidence of metabolic syndrome. Low intake of vitamin C by having an unhealthy diet, such as less consumption of fruits and vegetables, can increase the risk of developing metabolic syndrome (Wei *et al*., 2015; Traber *et al*., 2019). Vitamins C and E also have antioxidants that are positively related to oxidative stress. Oxidative stress plays a role in developing metabolic syndrome, including insulin resistance, high blood pressure, high lipid levels, inflammation, and endothelial dysfunction (Park *et al*., 2015). It occurs due to an imbalance between the production and the elimination of ROS or free radicals by the body's antioxidant system (Muhammad and Dienny, 2016).

In addition, abnormal metabolism at a productive age is closely related to a sedentary lifestyle or low physical activity. This association is due to changes in lifestyle in adolescents that are influenced by technological advances. A sedentary lifestyle is an activity in resting energy expenditure, such as sleeping, sitting, lying down, playing on the computer, and watching television (Pate *et al*., 2008). According to the National Basic Health Research (Riskesdas) 2018, the proportion of less physical activity in people aged >10 years is 33.5%. This proportion has increased by 26.1% from 2013 (Kemenkes RI, 2018). Several studies have shown that a sedentary lifestyle is positively related to the incidence of metabolic syndrome (Mitchell *et al*., 2018). One group that is more likely to experience this problem is the productive age group, namely college students. According to a study on medical students at Brawijaya University, 60% of the respondents have a low level of physical activity (Riskawati *et al*., 2018). Some factors that cause low physical activity in this age group are gender, educational level, social environment, self-efficacy, transportation, socioeconomics, and health status (Bauman *et al*., 2012).

Unfortunately, research that focuses on examining metabolic types concerning micronutrient intake and sedentary lifestyle has never been done in Indonesia. Based on this background, this study aims to analyze the differences in micronutrient intake, especially calcium, vitamin D, vitamin E, vitamin C, and sedentary lifestyle, between female college students with metabolically healthy normal weight (MHNW) and MUNW.

2. Materials and methods

2.1 Study design and subjects

This research was conducted at the Cito Clinical Laboratory Setiabudi Semarang. The study uses an observational method with a case-control study design. The data was collected from July 2020 to September 2020. This research has obtained ethical clearance from the Bioethics Commission for Medical/Health Research, Faculty of Medicine, Sultan Agung Islamic University, Semarang No. 209/VII/2020/Bioethics Commission.

This study's target population was all college students in Central Java, and the population was college students in Semarang City. The determination of the minimum sample size was determined based on the formula for a case-control study. The minimum number of subjects was twenty-two students with estimated dropout rates of 10% to 25% of subjects in each group. The sampling technique used was consecutive sampling by determining the subjects who meet the research criteria. These subjects are included in the study through a certain period until the number of respondents is met. Participants were selected based on inclusion criteria, such as willingness to be research subjects, female college students in Semarang City, aged 19-24 years, not consuming alcohol, not smoking, and having a BMI <25 kg/m^2. Also, they had to have two or more symptoms of metabolic disorder, such as waist circumference >80 cm, triglyceride levels ≥150 mg/dL, HDL cholesterol levels <50 mg/dL, blood pressure ≥130/85 mmHg, and fasting blood glucose levels ≥110 mg/dL. In addition, they had to have insulin resistance for the MUNW group and a BMI <25 kg/m^2 for the MHNW group without having

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metabolic disorders (<2 risks). Exclusion criteria were subjects who withdrew, and those who were ill during the research study. Based on the exclusion criteria mentioned, no subjects were included in the exclusion criteria.

The dependent variables in this study are the metabolic types, such as MUNW and MHNW. The independent variables are micronutrient intake (calcium, vitamin D, vitamin E, and vitamin C) and sedentary lifestyle.

2.2 Laboratory, anthropometric and clinical data collection

The research procedure begins with assembling students in Semarang City with a questionnaire via Google form. The screening activity began with the collection of anthropometric data, including height and weight. Height was measured using a microtoise with 0.1 cm accuracy and body weight using a digital measuring scale of 0.1 kg. Next, the author measured waist circumference with the OneMed metline band with a precision of 0.1 cm. Measurements were made by asking the subjects to remove their clothes in a closed chamber. Subjects were asked to stand up straight. Measurements were made at the approximate midpoint between the palpable lower ribs and the top of the pelvis. The author performed the blood pressure test using the Omron digital sphygmomanometer, and the results were presented on the LCD screen.

Laboratory tests related to metabolic syndrome components were conducted using the phlebotomy procedure, drawing venous blood samples using a syringe. The blood tests performed included fasting blood glucose using the hexokinase method, then triglyceride levels and HDL using the enzymatic method, and insulin using the ECLIA method. All tests were conducted at the CITO Clinical Laboratory Setiabudi Semarang with 105 college students as the subjects. Previously, the subjects were required to fast for 8-12 hrs before providing blood samples. Then, 50 students who met the inclusion criteria of the MHNW group and the MUNW group were selected. Next, the subjects were asked to complete the Semi-Quantitative–Food Frequency Questionnaire (SQFFQ) and the Adolescent Sedentary Activity Questionnaire (ASAQ), conducted through telephone interviews with each subject. The SQFFQ questionnaire was used to determine the micronutrient intake of the subject, which was then analyzed using NutriSurvey software. It was categorized as excessive if it was >120%, sufficient if it was 90%-120%, mild deficit if it was 70%-90%, and severe deficit if it was <70% of the total micronutrient needs in a day based on the RDA, which has been adjusted to the weight of each subject. The ASAQ questionnaire was categorized as low if it was <300 mins/day and high if it was >300 mins/day (Mandriyarani *et al.*, 2017)

2.3 Statistical analysis

The data that had been collected were tested for normality using the Shapiro-Wilk test. The differences in micronutrient intake, namely vitamin D, vitamin E, vitamin C, and sedentary lifestyle in MUNW and MHNW individuals, were determined. A Mann–Whitney U test was performed because the data were not normally distributed. Calcium intake was compared using the independent t-test because the data were normally distributed. The level of accuracy in the data analysis was 95%, or a p-value equal to .05. The relationship between micronutrient intake and sedentary lifestyle on metabolic disorder components was determined. A Pearson correlation test was performed for calcium, and Spearman's Rank correlation test was done for abnormally distributed data. This research was tested using SPSS 18.0 Windows software.

3. Results

3.1 Characteristics of subjects

All subjects in this study were female with ages ranging from 19 to 23 years, with a median of 21 years. The average BMI of the subjects was 21.5 kg/m^2. A total of 50 subjects were divided into two groups, the MHNW and MUNW groups, of 25 subjects.

Figure 1 describes the characteristics of subjects with MUNW and MHNW. The result found that the MHNW group comprised 14 subjects with no metabolic disorders (0 risks), and 11 subjects had one risk of a metabolic disorder. Within this group, 72.7% of the subjects had insulin resistance, 18.2% had central obesity, and 9.1% had low HDL. Whereas the MUNW group consisted of 15 subjects with two-component risks of metabolic disorders, with four subjects with central obesity and insulin resistance, three subjects with low HDL and insulin resistance, and three subjects with high blood pressure and insulin resistance, and others. Nine subjects had three components of metabolic disorders: most subjects, or 40%, had central obesity, insulin resistance,

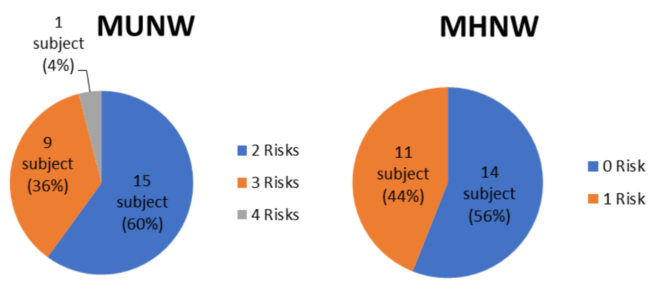

Figure 1. Characteristics subjects with MUNW and MHNW.

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and high blood pressure. Next, one subject had four metabolic disorders: central obesity, insulin resistance, hypertriglyceridemia, and low HDL levels.

Table 1 shows that almost all MUNW group components have higher mean values than the MHNW group. However, the MUNW group's HDL levels have a lower mean value (66.3±10.9) than the MHNW group (58±13.8). Then, the triglyceride levels in the MUNW group had far minimum and maximum values, which were 43 mg/dL to 309 mg/dL.

Besides that, Table 2 describes the components of metabolic disorders based on the metabolic type, the results showed that all components of metabolic disorders were mostly dominated by MUNW subjects. MHNW subjects had normal values regarding waist circumference, systolic and diastolic blood pressures, HDL levels, and triglyceride levels. Overall, the subjects in both groups had normal fasting blood glucose levels. More subjects in the MUNW group experienced insulin resistance, namely 19 subjects or 76%.

Table 3 shows the level of adequacy of micronutrient intake and sedentary activity in the two subject groups. The adequacy of micronutrient intake was obtained by comparing intake with each individual's daily micronutrient needs based on the RDA, adjusted to each subject's body weight. The calcium adequacy level in both groups consisting of 24 subjects (96%) was classified as a severe deficit (<70%), but in the MUNW group, one subject had an adequate calcium intake. The adequacy levels of vitamin D and vitamin E in both groups as a whole or 100% was classified as a severe deficit. The adequacy level of vitamin C, which was classified as excessive in the MHNW group, was 80%, and in the MUNW group, it was 52%. The level of sedentary activity in the MHNW and MUNW groups was classified as a high activity level (>300 mins/day): the MHNW group was 100%, and the MUNW group was 96%. A full description can be seen in Table 3.

Table 2. Components of metabolic disorders based on metabolic type.

Variable	n (%)	
	MHNW	MUNW
Waist Circumference		
Normal	23 (92)	10 (40)
Central Obesity	2 (8)	15 (60)
Systolic Blood Pressure		
Normal	25 (100)	17 (68)
High	0	8 (32)
Diastolic Blood Pressure		
Normal	25 (100)	16 (64)
High	0	9 (36)
Fasting Blood Glucose		
Normal	25 (100)	24 (96)
Hyperglycemia	0	1 (4)
HDL		
Low	1 (4)	9 (36)
Normal	24 (96)	16 (64)
Triglyceride		
Normal	25 (100)	18 (72)
Hypertriglyceridemia	0	7 (28)
Insulin Resistance		
Normal	17 (68)	6 (24)
Resistance	8 (32)	19 (76)

3.2 Differences in micronutrient intake and sedentary activity of college students based on metabolic type

After analyzing the different tests, there were differences in calcium, vitamin C, and vitamin E between the MHNW and MUNW groups ($p<0.05$). The average calcium intake in the MHNW group was 436.8 mg, whereas it was 261.2 mg in the MUNW group. The average intake of vitamin C was 323.3 mg in the MHNW group and 240 mg in the MUNW group. The average intake of vitamin E in the MHNW group was one mg, whereas, in the MUNW group, it was 0.7 mg. Meanwhile, the different vitamin D intake test results

Table 1. Minimum values, maximum values, mean values, and standard deviation of components of metabolic disorders based on metabolic type.

Variable	MHNW		MUNW	
	Mean±SD	Median (Min-Max)	Mean±SD	Median (Min-Max)
Waist Circumference (cm)	70.7±6.6	71 (61-86)	78.8±6.8	80 (65-89)
Systolic BP (mmHg)	110±7.3	109 (100-125)	118 ±13.6	122 (84-136)
Diastolic BP (mmHg)	73.4±6.4	73 (56-86)	80.8±9.9	81 (55-99)
FBG (mg/dL)	88.9±7.3	89 (74-102)	97±6.3	96 (84-110)
HDL (mg/dL)	66.3±10.9	65 (42-85)	58±13.8	57 (36-92)
Triglyceride (mg/dL)	66±23.5	59 (38-145)	105.6±59.4	90 (43-309)
HOMA-IR	1.87±0.9	1.63 (0.4-3.9)	3±1.4	2.5 (0.3-6.4)

BP: Blood Pressure, FBG: Fasting Blood Glucose.

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Table 3. Micronutrient adequacy levels and sedentary lifestyle in the MHNW and MUNW groups.

Variable	n (%)	
	MHNW	MUNW
Calcium Intake		
Severe Deficit	24 (96)	24 (96)
Mild Deficit	1 (4)	0
Adequate	0	1 (4)
Vitamin D Intake		
Severe Deficit	25 (100)	25 (100)
Vitamin C Intake		
Severe Deficit	2 (8)	9 (36)
Mild Deficit	2 (8)	1 (4)
Adequate	1 (4)	2 (8)
Excessive	20 (80)	13 (52)
Vitamin E Intake		
Severe Deficit	25 (100)	25 (100)
Sedentary Lifestyle		
High	25 (100)	24 (96)
Low	0	1 (4)

showed no difference in vitamin D intake between the MHNW and MUNW groups. The average vitamin D intake in the MHNW group was 1.4 mcg and 1.2 mcg in the MUNW group. There was a significant difference in sedentary activity between the MHNW and MUNW groups. The MUNW group spent more time doing activities, 703.4 mins/day (10 hrs 43 mins). In contrast, the MHNW group spent 515.8 mins/day (8 hrs 35 mins). Full results can be seen in Table 4.

Table 4. Analysis results of different tests of micronutrient intake and sedentary activity based on metabolic type.

Variable	MHNW	MUNW	p
	Mean±SD	Mean±SD	
Calcium Intake (mg)	436.8±101.3	261.1±173.2	0.000*[a]
Vitamin D Intake (mcg)	1.4±0.8	1.2±0.8	0.299[b]
Vitamin C Intake (mg)	323.3±208.4	240±365.4	0.013*[b]
Vitamin E Intake (mg)	1±0.9	0.7±1.3	0.011*[b]
Sedentary Lifestyle (mins/day)	515.8±148	703.4±218.9	0.002*[b]

*Significant p<0.05, [a] Independent t-test, [b] Mann–Whitney Test

3.3 The relationship between micronutrient intake and sedentary activity with metabolic components

Tables 5 and 6 describe the relationship between variables and metabolic components, including blood pressure, waist circumference, fasting blood sugar, HDL, triglycerides and HOMA-IR. The results showed that the correlation test showed a statistically significant relationship between calcium and all metabolic components except fasting blood glucose with a *p*-value <0.05. Calcium variables with waist circumference, blood pressure, HDL, TG, and HOMA-IR had negative correlation coefficient values (opposite directions). Meanwhile, calcium had a positive correlation coefficient (unidirectional) with HDL. The relationship of vitamin D with all metabolic components was statistically insignificant with a *p*-value > 0.05. The relationship of vitamin C with diastolic blood pressure and HDL was significant with *p*<0.05. Vitamin C and

Table 1. Minimum values, maximum values, mean values, and standard deviation of components of metabolic disorders based on metabolic type.

Variable	Waist Circumference		Systolic BP		Diastolic BP		FBG	
	r	p	r	p	r	p	r	p
Calcium[a]	−0.417	0.003	−0.328	0.02	−0.427	0.002	0.151	0.296
Vitamin D[b]	−0.125	0.386	−0.270	0.058	−0.166	0.248	0.123	0.395
Vitamin C[b]	−0.208	0.146	−0.245	0.087	−0.305	0.032	-0.122	0.397
Vitamin E[b]	−0.015	0.919	−0.343	0.015	−0.123	0.393	-0.179	0.213
Sedentary Activity[b]	0.273	0.055	0.141	0.328	0.318	0.024	0.090	0.533

[a] Pearson Test, [b] Spearman Rank Test

Table 6. Relationship between all variables and metabolic components such as HDL, Triglyceride, and HOMA-IR.

Variable	HDL		TG		HOMA-IR	
	r	p	r	p	r	p
Calcium[a]	0.308	0.03	−0.186	0.044	−0.315	0.026
Vitamin D[b]	−0.103	0.475	0.21	0.144	0.112	0.439
Vitamin C[b]	0.282	0.047	−0.107	0.458	−0.118	0.414
Vitamin E[b]	0.087	0.546	−0.058	0.688	−0.187	0.193
Sedentary Activity[b]	0.032	0.827	0.215	0.135	0.136	0.347

[a] Pearson Test, [b] Spearman Rank Test

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blood pressure had a negative correlation coefficient (opposite direction), whereas vitamin C and HDL had a positive correlation coefficient (unidirectional). Vitamin E showed a significant relationship with systolic blood pressure with $p<0.05$ with a negative correlation coefficient. Sedentary activity had a significant relationship with diastolic blood pressure with a positive correlation coefficient (unidirectional).

4. Discussion

4.1 Characteristics of subjects

The selected research subjects were students who had a BMI of <25 kg/m^2. They were grouped based on the components of their metabolic disorders. Subjects with normal BMI are often considered to have normal metabolism and a low risk of death from cardiovascular disease. However, out of 105 subjects with normal BMI who underwent screening, 33 subjects (31.4%) had at least two or more metabolic disorders, and the majority of subjects had insulin resistance (28 subjects) and central obesity (17 subjects). Research in Iran supports this study and shows that as many as 37.5% of subjects with a normal BMI have an abnormal metabolism (metabolically unhealthy) (Rahmanian *et al*., 2019). In addition, a study in Italy with subjects aged 19 to 90 years also found that 36.7% of the subjects with normal weight had metabolic disorders (Buscemi *et al*., 2017) Several studies illustrated the same thing. For instance, a study in individuals with normal BMI showed an increase in waist circumference, HbA1c, triglycerides, CRP levels, and a decrease in HDL levels (Eckel *et al*. (2015). Research in Korea (Choi *et al*., 2013) and Italy (Buscemi *et al*., 2017) reported that MUNW individuals have a significantly higher risk of death from cardiovascular disease than metabolically healthy obese individuals.

4.2 Differences in micronutrient intake and sedentary activity of students based on metabolic type

Currently, micronutrient intake's association with the incidence of metabolic syndrome is gaining recognition. There is a significant difference in calcium intake between students with the MHNW and MUNW metabolic types. Calcium intake in MHNW subjects was higher (436.8±101.3) than in the MUNW group (261.1±173.2). However, overall, both groups show an adequacy level that was classified as a severe deficit or <70% of the total daily needs. This was in agreement with the study on young adult women at the Faculty of Public Health Universitas Diponegoro that reported as many as 78.7% of subjects have a low calcium intake level (Parinduri *et al*., 2017). Based on the SQFFQ data, the sources of calcium intake that subjects consume the most are oats, milk and processed products, tempeh, tofu, and vegetables such as broccoli, spinach, and kale. The difference in the calcium sources between the two groups was in milk and processed products. The MHNW group consumed milk and its processed products five to seven times a week, whereas the MUNW group consumed these products less frequently, with a frequency of two to three times a week.

Although the mechanism between the protective factors of calcium consumption and metabolic syndrome was uncertain, it may be related to the ability of calcium to regulate energy metabolism (Zemel, 2002). In the cohort study on Insulin Resistance Syndrome (DESIR), it was found that with increased quartile levels of calcium intake in women, the concentration of insulin and blood pressure decrease, and HDL cholesterol increases (Drouillet *et al*., 2007). Calcium intake has a potential effect on blood pressure, insulin sensitivity, and cardiovascular disease risk. A study conducted on animals and humans showed that high calcium intake could reduce parathyroid hormone levels, affecting adipocyte metabolism by inhibiting lipogenesis and stimulating lipolysis (Zemel, 2002). This effect was consistent with this study's results, where calcium intake had a significant relationship with waist circumference and systolic and diastolic blood pressures, HDL, triglyceridemia, and insulin resistance. The lower the calcium intake, the higher the waist circumference, blood pressure, triglyceride levels, HOMA-IR, and the lower the HDL levels.

Vitamin D showed no significant differences between the MHNW and MUNW groups. The average intake of these two groups was also not too different. It was 1.4 mcg in the group without metabolic disorders and 1.2 mcg in the group with metabolic disorders. Both groups had an adequacy level that was classified as a severe deficit. A study also shows that vitamin D intake at 15-18 years was classified as a deficit, even though it was only 36.52% of the requirement based on the RDA (Saptarini, 2019). Based on SQFFQ data, the sources of vitamin D are fish, eggs, and milk. However, in both groups, fish consumption was quite rare, only once or twice a week in the amount of one-half to one fish in a single meal. The lack of vitamin D intake in these two groups was also because the body's need for vitamin D cannot be satisfied from the intake of food sources, since the amount of food containing vitamin D was very small. Besides, foods fortified with vitamin D are not enough to meet vitamin D needs (Rimahardika *et al*., 2017). In addition, this study did not find any significant relationship between vitamin D and all its metabolic components. A study in Korea showed that people with vitamin D deficiency have twice the risk of increasing

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fasting blood glucose (Kim *et al*., 2017). However, this study used serum levels of 25 (OH) D to examine the levels of vitamin D deficiency, in contrast to this study, which only observed vitamin D intake from food and supplements.

There were significant differences in the intake of vitamin C between the MHNW and MUNW groups. The level of vitamin C intake was considered excessive (>120% of the total daily requirement) in the MHNW group in as many as 20 subjects and the MUNW group in as many as 13 subjects. The high intake of vitamin C was because several subjects took vitamin C supplements during this pandemic. However, the MHNW group had a higher mean value of vitamin C intake (323.3±208.4) than the MUNW group (240±365.4). Sources of vitamin C intake were based on SQFFQ data separate from supplements. Vitamin C was also obtained from fruits such as guava, oranges, papaya, and vegetables such as broccoli, cauliflower, and spinach. The MHNW group consumed vegetables almost every day in the amount of 1-3 tablespoons. The frequency of vegetable consumption in the MUNW group was almost the same as in the MHNW group, but the average amount of vegetables consumed was only three tablespoons at one time.

Vitamin C (ascorbic acid) is a major hydrophilic antioxidant and an inhibitor of lipid peroxidation. A study showed that the intake of vitamin A >500 mg/day for three months could lower blood pressure. Current increasing evidence suggests that oxidative stress contributes to the etiology of hypertension. Therefore, antioxidants from food could affect blood pressure by reducing oxidative stress (Farag *et al*., 2019). In addition, this study aligns with a study from Korea on women >20 years old, which illustrated a significant relationship between vitamin C intake level and blood pressure. Following that, a study indicated that antioxidants could increase HDL levels by increasing Apo A1 mRNA in the liver, which plays a role in initiating the synthesis of Apo A1, the main component of HDL (Darni *et al*., 2016). This study also found a significant relationship between vitamin C intake, blood pressure, and HDL levels. The lower the vitamin C intake, the higher the blood pressure, and the lower HDL levels.

There was a significant difference in vitamin E intake between the MUNW group and the MHNW group. It was the same as calcium. Although there are significant differences, the adequate vitamin E intake level was classified as a severe deficit. However, the intake of vitamin E in the MHNW group was still slightly higher than in the MUNW group. Research in the United States also shows that 96.3% of women aged 19 years have deficient or insufficient intake of vitamin E (alpha-tocopherol) (Dror and Allen, 2011). According to SQFFQ data, vitamin E intake comes from broccoli, tomatoes, and carrots consumed by both groups. However, the amount of vegetables consumed by the MUNW group was less, namely about three tablespoons in one meal.

Vitamin E is a major hydrophobic antioxidant in cell membranes and circulating lipoproteins. Its relation to metabolic syndrome was the same as vitamin C: vitamin E was also a source of antioxidants from food. A diet containing foods rich in antioxidants, such as a source of vitamins C and E, can regulate levels of ROS (Bokov *et al*., 2004). ROS trigger the oxidation of low-density lipoprotein (LDL), accumulating in plaque and contributing to atherosclerosis and its pathogenesis (Rahman, 2007). Several mechanisms of action of nutritional antioxidants are neutralizing free radicals, reducing peroxide concentrations, improving membrane oxidation, encouraging iron to reduce ROS production, neutralizing ROS through lipid metabolism, and short-chain free fatty acids and cholesterol esters. A cross-sectional study from NHANES III reported that participants with metabolic syndrome had vitamin E concentrations and lower blood pressure than participants without metabolic disorders (Ford *et al*., 2003). This study also showed a significant relationship between the intake of vitamin E and systolic blood pressure. The lower the intake of vitamin E, the higher the blood pressure. However, it is still unknown whether increased antioxidant status reduces the risk of metabolic syndrome, although some studies have shown that higher serum antioxidant levels slow the progression of metabolic syndrome (Otto *et al*., 2012; Zhang *et al*., 2013). According to the results of research conducted on obese adolescents in Semarang, there was no significant relationship between the intake of vitamin E with the incidence of metabolic syndrome in adolescents because the intake of vitamin E in non-metabolic syndrome and metabolic syndrome subjects had an intake that was less than the daily intake requirement (Muhammad and Dieny, 2016).

A significant difference in sedentary lifestyle was found between the MHNW and MUNW groups. However, the group without metabolic disorders also had the same sedentary high activity as the group with metabolic disorders, which was >300 mins per day. Even though the two groups had relatively high activity, the group with metabolic disorders spent more time on sedentary activity. The MUNW group spent more time using social media while sitting or lying down and using their laptop, namely four to eight hrs/day. In contrast, the MHNW group spent three to five hrs/day on these sedentary activities. Technological advances have influenced this type of inactivity and have resulted in lifestyle changes, especially in adolescents and young adults. In addition, the high level of activity has also been influenced by the current pandemic conditions, which require students to study online.

One study showed that a one-hr increase in activity was associated with a 76% higher chance of developing metabolic syndrome (Mitchell *et al*., 2018). The longer the sitting period, the less frequent the skeletal muscle contractions, leading to decreased lipoprotein lipase activity and less glucose-stimulated insulin secretion. This sequence can lead to an increase in blood triglyceride levels and blood sugar levels (Otto *et al*., 2012). However, there was no significant relationship between sedentary activity, triglyceride levels and fasting blood glucose levels in this study. This study only discovered that physical activity showed a direct relationship with blood pressure, which means that the longer the duration of sedentary activity, the higher the blood pressure. This finding was because a long period of sitting will increase sympathetic nervous system activity, which increases blood pressure (Dempsey *et al*., 2018). An increase in sitting time is associated with an increased prevalence of metabolic syndrome by 1.16 times (Xiao *et al*., 2016).

The difficulty of reducing activities so far can be balanced by doing different physical activities, including leisure-time physical activity (LTPA). LTPA include various activities, such as walking, dancing, gardening, swimming, cycling, and others. Compared with inactive individuals, the risk of metabolic syndrome decreased by 8% every time there was an increase in LTPA by 10 MET (metabolic equivalent of task) hrs/week (Zhang *et al*., 2017). WHO recommends that individuals aged between 18 and 64 years perform at least 150 mins of moderate-intensity aerobic physical activity or at least 75 mins of vigorous-intensity physical activity or an equivalent combination of modern- and vigorous-intensity physical activity (World Health Organization, 2020). A meta-analysis was conducted with a total of 77,000 participants diagnosed with metabolic syndrome. In this study, the aerobic exercise group decreased BMI, waist circumference, blood pressure, GDP, and LDL compared with the sedentary group (Ostman *et al*., 2017). This study also showed that increasing moderate physical activity for at least 1 hr, accompanied by consuming food intake that is rich in vitamin C, can effectively reduce the risk of metabolic syndrome (Kim and Choi, 2016).

4. Conclusion

There were differences in calcium, vitamin C, vitamin E, and sedentary lifestyle among female students based on their metabolic types, namely MHNW and MUNW. Micronutrient intake (calcium, vitamin C, and vitamin E) in the MHNW group was higher than that in the MUNW group. It differed significantly, although the level of adequacy in both groups was classified as a deficit. The activity of the two groups was considered high >300 mins/day. However, the duration of a sedentary lifestyle for the MUNW group (703.4 mins/day) was higher than for the MHNW group (515.8 mins/day).

Conflict of interest

The authors declare no conflict of interest.

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