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Metabolic characteristics and nutrition intake on women with normal body mass index

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Abstract

Metabolic syndrome can be found on an individual with normal weight (Metabolically Obese Normal Weight/MONW). Eating habits and lifestyle changing in early adulthood can be the risk of metabolic syndrome in person with a normal body mass index (BMI). The purpose of this study was to identify metabolic characteristics in women with normal BMI and to analyze the correlation of nutrition intake with metabolic syndrome on women with normal BMI. This is an observational study with a cross-sectional design at five offices in Semarang. The sample in this study was 64 subjects. Inclusion criteria of study subject were women aged 25-40 years and BMI <25 kg/m^2. Study subject was chosen by using a consecutive sampling method. The data of nutrition intake was obtained by using the Food Frequency Questionnaire. HDL cholesterol, fasting blood glucose and triglyceride were analyzed. Analysis data was conducted by using Pearson correlation and Rank Spearman. MONW was present in 10.9% and more than 50% had pre metabolic syndrome. A total of 51.6% of the subjects had central obese and 26.6% had low HDL cholesterol. About 14.1% of the subjects have hypertension. There was a positive correlation between energy, fat intake and waist circumference. Carbohydrate intake was positively correlated with fasting blood glucose and triglyceride. The higher protein intake, the higher HDL cholesterol. The most common indicator of metabolic syndrome on women with normal BMI was central obesity and low HDL cholesterol. The factors related to the prevalence of metabolic syndrome on women with normal BMI was macronutrient intake.

1. Introduction

Adulthood is a productive age in which the body needs optimal nutrition for activities. In this period there is no increase in energy required because the growth and development have stopped (Thorpe *et al.*, 2014; Hizni, 2016). An adult usually can earn money, it makes them tend to have more ability to choose the food they consume. It causes changes in their diet. In the other hand, an adult is required to work productively in which the activity is mostly in a position of sitting so that physical activity of adult tend to be low (Kant *et al.*, 2013).

Diet and lifestyle changes in early adulthood can be the initiation of degenerative diseases. The study about diet conducted in Department of Health South Sulawesi showed that 62% respondents had poor diets which were high carbohydrate and fat and low fiber so that it can be one of the risk factors of degenerative diseases (Nadimin, 2011). Another study about the dietary pattern on employees of Alfa Star Buana company and PLS Ervina Medan showed that employees had poor diets which were high energy intake and low fiber as 72% (Zahra *et al.,* 2013).

Several studies had shown that there was a correlation of dietary pattern and the impact on health parameters such as Body Mass Index (BMI), cholesterol level, and blood tension. A good diet can be a protective factor toward metabolic syndrome, cardiovascular disease, obesity and hypertension (Splett and Krinke, 2011; Sun *et al.*, 2014). A good diet is a balanced nutrition in term of quality and quantity. The quality diet can indicate whether the food consumed is in accordance with the recommendations. High quality diet is a diet

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which can meet the nutritional needs of an individual to achieve optimum health. Balanced nutrition can keep the body in healthy without gaining weight by having high fiber, low cholesterol, low saturated fat and low sodium and adequate macronutrient (Kementrian Kesehatan Republik Indonesia, 2014; Alkerwi, 2014).

One of the nutritional problems which has a high prevalence in adulthood is metabolic syndrome (MS) in which someone with MS has minimally three metabolic disorder which indicated by the high fasting blood glucose level, hypertension, dyslipidemia, and central (Dodd, 2012; Suliga *et al*., 2015). One epidemiology data stated that world MS prevalence is 20-25%. The result of Framingham Offspring Study found that in respondent at the age of 26-82 years, there was 29,4% male and 23.1% female had MS (Sihombing and Tjandrarini, 2015). The data from Himpunan Studi Obesitas Indonesia (HISOBI) shows that MS prevalence in Indonesia is 13.13% (Rini, 2015). Another study conducted in Medan in 2012 describe MS prevalence on obese persons were 66% and on the nonobese persons was 28% (Mutiara, 2013).

The main factors that cause metabolic syndrome are abdominal obesity, but in fact, metabolic syndrome can also be found in individuals of normal weight. People with normal weight and metabolic syndrome are known as Metabolically Obese Normal Weight (MONW). The criteria in determining a MONW are if an individual has a normal BMI (18.5 - 24.9 kg/m^2), accompanied by (1) a minimum of three of the five criteria for metabolic syndrome, or (2) has a TyG index is above the normal limit, or (3) the results of Homeostasis Model Assessment (HOMA) test on insulin resistance is in the highest quartile (Lee *et al*, 2015). Research in some populations shows that non-obese adults who have metabolic syndrome have a prevalence of 14.7 - 59% (Suliga *et al*., 2015). Other studies have also shown that the prevalence of metabolic syndrome in normal-weight individuals is 17.27% (Suliga *et al.,* 2016). About 24% of the adult population in America has a diagnosis of MONW is at risk of developing chronic disease (Bradshaw *et al.,* 2013). The study about prevalence and characteristic metabolic of women with normal BMI is still rarely done. Previous studies in Norway aimed to analyze the relationship between dietary pattern qualitatively with the prevalence of metabolic syndrome in normal weight (Suliga *et al*., 2015). In this study, the metabolic characteristics of women with MONW were studied and the correlation between nutrition intake quantitatively and metabolic syndrome in normal weight were studied.

2. Materials and methods

This was an observational study with cross sectional design in 5 offices in Semarang city which was Balai Besar Teknologi Pencegahan Pencemaran Industri (BBTPPI), Dinas Pekerjaan Umum (DPU), Dinas Perindustrian dan Perdagangan (Disperindag), Dinas Tenaga Kerja dan Perhutani. The study was conducted in May-October 2018. The sample size in this study was 64 subjects. Inclusion criteria for the subjects of this study were women aged 25-40 years, BMI <25 kg/m^2, not currently undergoing a special diet, not pregnant, not smoking and drinking alcoholic beverages and were willing to participate in the study by filling the Informed Consent form. The subjects were taken by consecutive sampling. The independent variable was nutrition intake consisting of energy, protein, fat, carbohydrate, fiber and sodium intake. The dependent variable was metabolic syndrome components.

The intake of energy, protein, fat, carbohydrates, fiber and sodium is the average intake of energy, protein, fat, carbohydrates, fiber and sodium in a day from food, drinks and supplements obtained by interviewing food intake in the past 1 month using the Semi Quantitative Food Frequency (SQ FFQ) method. Data on food intake collected was then analyzed using Nutrisurvey software. An adequate level of energy of protein, fat, carbohydrate, fiber and sodium was obtained by comparing the intake of nutrients with individual needs. Metabolic syndrome was a clinical condition where there are a number of metabolic disorders, namely insulin resistance, dyslipidemia (high triglyceride levels and low levels of high-density lipoprotein (HDL)), high blood pressure and central obesity. Fasting blood glucose was categorized as high when it was ≥ 100 mg/dL. Waist circumference was categorized at risk to health if it was > 80 cm (women). Triglyceride level was categorized to be high when ≥150 mg/dL and HDL was expressed low when it was <50 (women). Hypertension was defined when blood pressure >120/80 mmHg. Subjects were categorized as metabolic syndrome if they had at least 3 of 5 signs. Blood pressure was measured with the use of the blood pressure monitor Omron. The test was carried out on the artery of the left upper arm. The average of the two measurements was analyzed. Blood samples were collected by vein puncture after an overnight fast. All samples were analyzed in a commercial laboratory in Semarang city, Indonesia with the standard methods.

Univariate analysis was used to describe the frequency distribution table of the studied variables. Bivariate analysis is used to determine the correlation between the independent variables and the dependent variable. Bivariate analysis was conducted by using Chi-

Square test. Data analysis was conducted using SPSS.

3. Results

The subjects were sixty-four women with a mean age of 31 years and a mean BMI of 22.31 kg/m^2 (Table 1). Meanwhile, the average waist circumference of the subject was 79.28 cm with a minimal value of 68 cm and a maximal value of 90.5 cm. The mean waist circumference of the subjects was almost 80 cm where the value was the cut off point for the metabolic syndrome indicator according to NCEP-ATP III for Asians (Thomas *et al.,* 2005). The average fasting blood glucose level of the subject was only 81.28 mg /dL with the highest value of 111 mg/dL.

As an indicator of dyslipidemia, the mean of triglycerides level for all subjects was 77.27 mg/dL with a high standard deviation as 31.97 mg/dL which means that the triglyceride values in this study varied greatly. This is evidenced by the lowest triglyceride level which was 21 mg/ dL while the highest value was 221 mg/dL. However, this is very different from the HDL level. The mean of HDL cholesterol level of the subjects was 54.88 mg/dL with the lowest value of 37 mg/dL and the highest value of 77 mg/dL. This mean was above the cut-off point indicator of metabolic syndrome for HDL which is <50 mg/dL (Thomas *et al.,* 2005). Meanwhile, the subjects have a mean systolic blood pressure value of 106/72 mmHg where this value is normal compared to the cut-off point indicator of metabolic syndrome for blood pressure that was 135/85 mmHg (Thomas *et al.,* 2005).

Mean of all nutrition intake was above 70% of total Calories, except for fiber intake which was only 50.58%. Interestingly, all variables have a standard deviation of more than 16%. This showed that all nutrition intake levels have a high variation in values and have a wide range between the minimum and maximum values. For example the adequacy level of fiber intake which has the lowest value of 16.56% while the highest value was 198.5%.

About 11% of subjects were classified as metabolic syndrome and 51.6% were classified as pre-metabolic syndrome (Table 2). About 37.5% of the subjects have no sign of metabolic syndrome. Among the five indicators of metabolic syndrome, waist circumference is an indicator of metabolic syndrome with the highest proportion of 51.6% compared to fasting blood glucose levels, triglyceride levels, HDL cholesterol levels, and blood tension. This means that half of the subjects included central obesity or had a waist circumference of more than 80 cm. In contrast, fasting blood glucose and triglyceride level was no more than 4%. Meanwhile, from all subjects, only 14.1% had blood tension above 130/85 mmHg and 26.6% of them had HDL cholesterol level <50 mg/dL.

Among all the intake variables, only the energy and macronutrient intake variables are related to the metabolic syndrome indicator. Meanwhile, the intake of fiber, sodium, saturated fat, and unsaturated fat had no correlation with metabolic syndrome indicators. Pearson correlation test results that the energy and fat intake is significantly correlated with waist circumference. Carbohydrate intake positively related to fasting blood glucose and triglyceride levels. Interestingly, Protein intake has a correlation with HDL cholesterol levels. Meanwhile, there was no intake variable correlated with blood tension.

4. Discussion

Metabolic syndrome is a clinical condition where

Table 1. Characteristic of subject

Variable	Mean±SD	Minimum	Maximum
Age (year)	31.12±4.83	25	40
Body Mass Index (kg/m^2)	22.31±1.9	18	24,90
Waist circumference (cm)	79.28±5.14	68	90,5
Fasting Blood glucose (mg/dl)	81.28±9.19	60	111
Triglyceride (mg/dl)	77.27±31.97	21	221
HDL Cholesterol (mg/dl)	54.88±9.34	37	77
Systolic blood tension (mmHg)	106.25±13.97	90	135
Diastolic blood tension (mmHg)	72.34±9.92	60	100
Energy intake (%)	91.15±19.47	49.03	130.75
Carbohydrate intake (%)	86.29±16.92	47.06	117.58
Protein intake (%)	73.39±22.67	39.66	157.26
Fat intake (%)	90.05±17.67	40.46	124.71
Fiber intake (%)	50.58±28.80	16.56	198.5
Sodium intake (%)	81.75±42.75	15.85	187.67
Saturated Fat intake (%)	152.04±44.20	62.09	250.58
Unsaturated fat intake (%)	81.7142±29.31	36.27	167.55

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Table 2. Description of metabolic syndrome of study subject

Metabolic Syndrome Indicators	Category	n (%)
Metabolic Syndrome	Non- Metabolic Syndrome	24 (37.5)
	Pre- Metabolic Syndrome	33 (51.6)
	Metabolic Syndrome	7 (10.9)
Waist circumference	Normal	31 (48.4)
	Obese	33 (51.6)
Fasting Blood Glucose	Normal	63 (98.4)
	High	1 (1.6)
Triglyceride	Normal	62 (96.9)
	High	2 (3.1)
HDL Cholesterol	Normal	47 (73.4)
	Low	17 (26.6)
Blood Tension	Normal	55 (85.9)
	Hypertension	9 (14.1)

there are a number of metabolic disorders, those are insulin resistance, dyslipidemia (high triglyceride levels and low levels of high density lipoprotein (HDL)), high blood tension and central obesity. According to NCEP ATP III for Asians, a person is considered to have metabolic syndrome when there are signs of at least 3 out of 5 signs of metabolic disorders; those are fasting blood glucose ≥ 100 mg/dL, waist circumference ≥90 cm for men and ≥80 cm for women, triglycerides levels ≥ 150 mg/dL, HDL cholesterol levels <50 (women), and blood tension ≥ 130/85 mmHg (Thomas *et al.,* 2005*)*.

Most people with central obesity had metabolic syndrome, but in fact, metabolic syndrome can also be found in individuals of normal weight. St-Onge *et al*. (2004) in his study stated that in the United States, 4.6% of normal weight men and 6.2% of normal weight women had metabolic syndrome. Meanwhile, the prevalence of metabolic syndrome in the Iranian population with normal weight was higher compared to the United States of America which is 9.9% on men and 11.0% on women. Whereas in East Asia, a cross-sectional study conducted in a non-obese Taiwan population showed that 18.7% of nonobese subjects had metabolic syndrome (Geetha *et al.*, 2011). This study showed that women aged 25-40 years with normal BMI who had a metabolic syndrome of 10.9%.

Characteristics of the components of metabolic syndrome that mostly occur in women with normal BMI (<25 kg/m^2) in this study are having waist circumference above the normal limit (51.6%) and low HDL cholesterol levels (26.6%) (Table 2), while other components such as fasting blood glucose, triglyceride levels, and blood pressure do not frequently occur in the subject. It was reported by He *et al*. (2015) that increased waist circumference and low levels of HDL cholesterol are correlated with visceral fat accumulation causing central obesity. Central obesity is correlated with excessive release of non-esterified fatty acids in the liver so that it can induce insulin resistance. The presence of insulin resistance results in an increase in HDL catabolism and interference with HDL particle maturation. Thus, the presence of central obesity was accompanied by low levels of HDL (He *et al.*, 2015).

Bivariate analysis showed that there was a significant relationship between waist circumference with adequate levels of energy and fat intake. The results of this study are similar to those of Nikbazm *et al*. (2013) where a positive correlation was found between waist circumference with energy intake and fat intake on women. Another study by Burini *et al*. (2017) also showed a significant relationship between waist circumference with total energy intake, with a weak positive correlation. Meanwhile, the correlation value between waist circumference with energy and fat intake respectively 0.464 and 0.443 which means it has a moderate positive correlation. It means that the higher the total energy and fat intake, the greater the subject's waist circumference would be.

Limitation of total dietary fat intake as a "low fat" diet concept is usually accompanied by a limitation of total calories. Low-fat diets accompanied by energy restrictions are known to be effective in improving metabolic syndrome parameters, including body composition, blood tension, plasma lipids, inflammatory markers, and insulin sensitivity (Andersen and Fernandez, 2013). Research in 50 obese male and female subjects with metabolic syndrome given the hypocaloric diet (500 kcal/day) by consuming whole wheat for 12 weeks has a significant decrease in waist circumference, weight, and body fat percentage (Katcher *et al.*, 2008).

Low-fat diets without limiting energy intake can actually increase plasma triglycerides and reduce HDL levels, thus increasing the risk of metabolic syndrome. Likewise, high fat diets without carbohydrate restriction can also increase poor metabolic output. Interestingly, high-fat diets (42% of total energy) has been shown to change adipocyte progenitor cell populations and gene expression profiles in mice. In addition to impairing glucose tolerance and insulin sensitivity, high-fat feeding reduces the population of adipocyte progenitor cells in thermogenic brown adipose tissue, while also increasing vascular dysfunction and oxidative stress in the arteries of perivascular adipose tissue. Based on these findings, it may be necessary to consider optimizing the intake of fatty acids (saturated or unsaturated) rather than reducing total fat intake in the treatment of metabolic syndrome (Andersen and Fernandez, 2013).

It is known from the correlation test, carbohydrate intake has a significant correlation with fasting blood glucose and triglyceride levels (Table 3). This is similar to the research of Song et al. which shows that triglyceride, HDL, and fasting blood glucose levels are related to the percentage of energy from carbohydrates in men and white rice intake in women. While some studies in Asian populations found that carbohydrate consumption has a stronger correlation with metabolic syndrome in women than men (Song *et al.*, 2014).

A study conducted on animal had shown that limiting carbohydrate intake has beneficial effects on several parameters of the metabolic syndrome. Hypertriglyceridemia mice as a metabolic syndrome model given high intake of sucrose showed increased VLDL secretion, decreased oxidation of free fatty acids (FFA), and increased synthesis of de novo FFA synthesis from glucose. But the opposite effect occurs in rats given high fat food. These changes result in an increase in plasma triglycerides and free fatty acids in the high-sucrose group compared to the high-fat intake group. A study conducted on human studies had shown that carbohydrate restriction can prevent liver steatosis and metabolic syndrome. Furthermore, limiting carbohydrate intake has been shown to be more effective in reducing liver triglycerides than limiting calorie intake in subjects with non-alcoholic fatty liver disease (NAFLD) (Andersen and Fernandez, 2013).

In this study, there was a significant correlation between protein intake and HDL cholesterol levels with significant positive correlation (r= 0.258). This shows that the higher the protein intake, the higher HDL levels would be. Research Dessein *et al*. (2000) showed similar results that a high-protein carbohydrate restriction diet (1600 kcal, 40% of carbohydrate, 30% of protein, and 30% of fat) for 4 months was able to significantly increase HDL levels. A proportional increase in protein intake has been shown to increase insulin sensitivity.

There is a correlation between HDL levels and insulin sensitivity. Most cases of low HDL levels are closely related to conditions of insulin resistance and hypertriglyceridemia. Hypertriglyceridemia conditions often cause insulin resistance which is a trigger in reducing plasma HDL levels. The existence of insulin resistance would cause a disruption in the absorption of free cholesterol in peripheral cells as a result of mutations in the ABC-A1 gene. In addition, insulin resistance also results in impaired free cholesterol esterification as a result of LCAT deficiency (Lecithin Cholesterol Ester Transfer Protein) which is a protein that plays an important role in the formation of HDL, as well as lipoprotein lipase mutations or mutations in the

Table 3. Correlation of energy, fat, carbohydrate, protein, fiber, sodium, saturated fat, and unsaturated fat intake with metabolic syndrome indicators

Variables	Waist circumference	GDP	Triglyceride	HDL	Systolic	Diastolic
Energy intake	**p: 0.00[a]** **r: 0.464**	p: 0.16[a] r: 0.176	p: 0.246[a] r: 0.147	p: 0.62[a] r: -0.063	p: 0.239[b] r: -0.149	p: 0.431[b] r: -0.1
Carbohydrate intake	p: 0.72[a] r: 0.226	**p:0.009[a]** **r: 0.325**	**p: 0.02[a]** **r: 0.372**	p: 0.079[a] r: -0.221	p: 0.083[b] r: -0.218	p: 0.122[b] r: -0.195
Protein intake	p: 0.057[a] r: -0.239	p:0.977[a] r: 0.004	p: 0.515[a] r: -0.083	**p: 0.04[a]** **r: 0.04**	p: 0.345[b] r: -0.12	p: 0.29[b] r: -0.134
Fat intake	**p: 0.00[a]** **r: 0.443**	p:0.558[a] r: 0.075	p: 0.733[a] r: 0.043	p: 0.887[a] r: -0.018	p: 0.432[b] r: -0.1	p: 0.906[b] r: 0.015
Fiber intake	p: 0.704[a] r: -0.048	p:0.061[a] r: -0.235	p: 0.086[a] r: -0.217	p: 0.502[a] r: 0.085	p: 0.777[b] r: 0.036	p: 0.611[b] r: 0.065
Sodium intake	p: 0.389[a] r: 0.109	p:0.951[a] r: 0.008	p: 0.994[a] r: 0.000	p: 0.558[a] r: 0.075	p: 0.668[b] r: -0.055	p: 0.951[b] r: -0.008
Saturated fat intake	p: 0.664[a] r: 0.055	p:0.466[a] r: 0.093	p: 0.548[a] r: 0.077	p: 0.79[a] r: -0.034	p: 0.699[b] r: -0.049	p: 0.555[b] r: 0.075
Unsaturated fat intake	p: 0.451[a] r: -0.096	p:0.227[a] r: 0.153	p: 0.176[a] r: -0.171	p: 0.125[a] r: 0.194	p: 0.438[b] r: -0.099	p: 0.563[b] r: -0.074

[a] Pearson, [b] Rank Spearman

apoA-1 gene thereby delaying HDL increase. All of these factors can interfere with HDL catabolism (Rashid *et al.*, 2003). From the causality correlation above, it can be concluded that if there is an increase in protein intake, there will be an increase in insulin sensitivity and decrease insulin resistance and reduce HDL catabolism.

5. Conclusion

The most common indicator of metabolic syndrome on women with normal BMI was central obesity and low HDL cholesterol. The factors related to the prevalence of metabolic syndrome on women with normal BMI was macronutrient intake such as fat, protein, and carbohydrate intake. Further research on the relationship of nutrition intake with metabolic syndrome in people with normal body mass index needs to focus on dietary patterns qualitatively to better explain about dietary patterns that are risk factors for metabolic syndrome.

Conflict of Interest

The authors declare that there is no conflict of interest.

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