STRADA Jurnal Ilmiah Kesehatan
DOI: 10.30994/sjik.v10i1.586
ISSN: 2252-3847 (print); 2614-350X (online) Vol.10 No.1 May 2021 Page. 186-196

Correlation between Fiber Intake and Insulin Resistance in Normal and Overweight Employees in Jakarta

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ABSTRACT

Insulin resistance is the basis for various diseases such as type 2 diabetes, hypertension, cardiovascular disease, and metabolic syndrome. Insulin sensitivity can be improved through lifestyle changes, such as weight loss, regular physical activity, and a high-fiber diet. Employees who work in offices are a group at risk for insulin resistance associated with inadequate physical activity, high workload, smoking habits, and a diet that tends to be high in carbohydrates, fat, and less fiber. Preventing disease in workers is important because it can improve the health which in turn will increase worker productivity which will affect economic growth in Indonesia. This study aims to determine the correlation between fiber intake and insulin resistance in normal and overweight employees in Jakarta. This study is a cross-sectional study of 58 employees of a pharmacy company aged 19-49 years with normal or overweight and normal blood sugar. BMI, waist circumference, physical activity, smoking status and food intake were assessed. The fiber intake was assessed by 3 days estimated food record and the insulin resistance was assessed by HOMA IR obtained from fasting blood sugar and insulin. Data analysis technique used the Spearman Correlation test with the Statistical Package for Social Science (SPSS). Result obtained fiber intake and HOMA IR has $r = -0.390$ and $p = 0.002$. Based on the result of the study, it can be concluded that there is a negative correlation between fiber intake with insulin resistance in normal and overweight employees in Jakarta.

Keywords: Dietary Fiber Intake, Employees; HOMA IR, Insulin Resistance

Received December 23, 2020; Revised January 22, 2020; Accepted February 10, 2021

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ISSN: 2252-3847 (print); 2614-350X (online) Vol.10 No.1 May 2021 Page. 186-196

BACKGROUND

Insulin resistance is the basis for the occurrence of various diseases such as type 2 diabetes, hypertension, cardiovascular disease, and metabolic syndrome (Breneman, 2011). Based on Riskesdas 2018, the prevalence of diabetes mellitus increased from 6.9% in 2013 to 8.5% in 2018 (Balitbangkes, 2018). Insulin sensitivity can improved through lifestyle changes, especially weight loss and regular physical activity. In addition, the literature suggests that a diet high in fiber as well as low in fat is associated with increased insulin sensitivity. Eating a healthy diet can ease the pathogenesis of insulin resistance, thereby reducing the risk of type 2 diabetes and cardiovascular disease (Breneman, 2011).

Survei Konsumsi Makanan Individu (SKMI) in 2014 showed that the average consumption of vegetables and fruit in the 19-55 year age group was 116.4 g/day, this number is still very far from the adequacy of vegetables and fruits according to balanced nutrition guidelines, at least 400 g/person/day (Hermina, *et al*., 2016). Meanwhile, according to Riskesdas 2018 as many as 95.5% of Indonesians consume <5 servings of fruit and vegetables/day, vegetables and fruit are sources of fiber (Balitbangkes, 2018). This is still lacking when compared to the suggestion from World Health Organization (WHO) recommendations to consume 5 servings of fruits and vegetables a day. Based on a study in Jakarta, it was stated that 17.40% of employees consumed less vegetables and fruit, and 72% of employees consumed very little fruits and vegetables (Astuti, *et al*., 2016). Another study stated that the average employee fiber consumption was only 12.77 g/day (Christina, *et al*., 2011).

Employees who work in offices are a group at risk for diseases such as diabetes, cardiovascular, and metabolic syndrom (Ryu, *et al*., 2016). This is associated with inadequate physical activity where they spend more than 8 hours in the office and 2 to 4 hours on the road which makes no time to move actively (Abadini, *et al*., 2019). Other factors are high workload, smoking habits, and a diet that tends to be high in carbohydrates and fats (Ryu, *et al*., 2016, Kamso, *et al*., 2011). Types of work are thought to be related to the occurrence of insulin resistance. Offices such as managers and administrative staff have a higher risk of insulin resistance than employees who work as laborers, fishermen, or farmers (Kwon, *et al*., 2013).

A previous study found that overweight people had a 48.7% incidence of insulin resistance (Govers, 2015). A cohort study examining the incidence of prediabetes in subjects with normal weight and overweight for 5.5 years found a 26% incidence of prediabetes (Owei *et al*., 2017). Therefore, prevention is needed in risk groups with normal and overweight in order to avoid insulin resistance.

Preventing disease in workers is important because it can improve the health which in turn will increase worker productivity. High worker productivity has a significant effect on economic growth in Indonesia (Ramayani, *et al*., 2012).

Study on the correlation between fiber intake and insulin resistance has never been conducted in the population of employees in Jakarta. This prompted a study entitled "Correlation between Fiber Intake and Insulin Resistance in Normal and Overweight Employees in Jakarta".

METHODS

Study Participants

This study is a cross-sectional study conducted in November 2020 - December 2020 on administrative/managerial workers aged 19-49 years, with a body mass index (BMI) 18.5-24.9 kg/m^2, and fasting blood sugar <100 mg/dL in a pharmacy company in Jakarta,

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Indonesia. Subjects were selected using consecutive sampling. We excluded subjects with a history of prediabetes, diabetes, coronary heart disease, PCOS, dyslipidemia, and hypertension. Another exclusion was taking antidiabetic drugs, slimming drugs, carbohydrate blockers, beta blockers, diuretics, corticosteroids, antipsychotics, antiviral against HIV, pregnant and lactating women. This study protocol was approved by the Research Ethics Committee, Faculty of Medicine, University of Indonesia (KET-1339/UN2.F1/ETIK/PPM.00.02/2020) and written consent was obtained from each subject. We used a questionnaire to assess subject characteristics, and a validated Global Physical Activity Questionnaire (GPAQ) Indonesian version was used to obtain physical activity data.

Intake Assessment

Intakes of fiber, energy, carbohydrates, and fat were assessed using the 3-days estimated food record method, consisting of two working days and one day off. The food intake will then be analyzed using NutriSurvey 2007 (Germany).

Anthropometric Measurements

Height and weight measurements were carried out according to standard procedures using a stadiometer with an accuracy of 0.1 cm and a digital scale (SECA GmbH, Hamburg, Germany) with an accuracy of 0.1 kg. Body mass index (BMI) is calculated as body weight (in kilograms) divided by height squared (in meters). A measuring tape (SECA GmbH, Hamburg, Germany) was used to measure waist circumference to an accuracy of 0.1 cm.

Blood Sample

Assessment of insulin resistance was carried out by assessing the subject's HOMA IR levels. HOMA IR is obtained by the formula: (fasting glucose (mg/dL) x fasting insulin (mU/dL)) / 405). Blood samples were collected by fasting for 12 hours, then blood was taken to the Biochemistry Laboratory, Faculty of Medecine, Universitas Indonesia, to obtain fasting blood sugar levels and fasting insulin. Testing of fasting insulin was carried out using the ELISA method and examination of fasting blood sugar was carried out using the Folin-Wu method. Then it was calculated using the formula to get the IR HOMA value.

Statistics analysis

Static analyzes were performed using the Statistical Package for the Social Sciences (SPSS Ins., Chicago, IL, USA) version 20.1. Descriptive analysis was performed to analyze continuous variables in a normal distribution using mean ± standard deviation. Meanwhile, the median value (min-max) is used if the distribution is not normal. The bivariate test in the form of Spearman correlation was used to assess the correlation between fiber intake and the subject's HOMA IR levels. Findings were considered statistically significant if $p < 0.05$.

RESULT

A total of 60 employees had blood samples taken, but there were 2 employees who were excluded because the blood sugar was higher than 100 mg/dL. The total included in the analysis was 58 subjects. Subject characteristics can be seen in Table 1.

In the limited age characteristics of 19-49 years, the subjects had a mean value of 30 (19-45) years with the majority being female (60.3%). Most of the research subjects had normal nutritional status (60.3%) with an average BMI of 22.1±1.67 kg/m^2. Waist circumference had a mean value of 74 (59 - 98) cm and only a small proportion was included

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in abdominal obesity (17.2%). Only a small proportion of subjects were active smokers (20.7%) and most of the subjects had a low level of physical activity (65.5%). The subject's fasting blood sugar level had a mean of 86.79± 9.08 mg/dL, the subject's fasting insulin level had a mean value of 6.63 (0.53-37.40), and the subject's HOMA IR level had a mean value of 1.47 (0.10-7.24) units.

The subject's fiber intake had a mean value of 7.7 (2.70-37.80) grams/day with the majority of subjects included in the poor fiber adequacy group based on AKG (94.8%). The energy intake of the subjects averaged 1626.66±519.66 kcal/day and the majority of subjects were included in the insufficient energy adequacy group (69%). The average subject's carbohydrate intake was 220.23±81.66 grams/day and 53.88% of the total energy. The majority of subjects were included in the poor carbohydrate adequacy group (84.5%). The average subject's fat intake was 57.74±22.66 grams/day and 32.21% of the total energy. According to the AKG, 53.4% of subjects were included in the fat adequacy group.

Table 1. Subject characteristics

Variable	Result (n=58)
Age (year)	30 (19 – 45)*
Gender, n (%)	
Male	23 (39,7%)
Female	35 (60,3%)
BMI (kg/m^2)	22,1 $\pm$ 1,67**
Nutritional status, n (%)	
Normal weight	35 (60,3%)
Overweight	23 (39,7%)
Waist circumference (cm)	74 (59 – 98)*
Classification of waist circumference, n (%)	
Normal	48 (82,8%)
Abdominal obesity	10 (17,2%)
Physical activity, n (%)	
High	20 (34,5%)
Low	38 (65,5%)
Smoking status, n (%)	
Smoking	12 (20,7%)
Non Smoking	46 (79,3%)
Total fiber intake (g/day)	7.7 (2.70 – 37.80)*
Total fiber intake group, n (%)	
Inadequate ($\leq$77% AKG)	55 (94,8%)
Adequate (>77% AKG)	3 (5,2%)
Energy intake (kcal/day)	1626,66 $\pm$ 519,66**
Inadequate ($\leq$77% AKG)	40 (69%)
Adequate (>77% AKG)	18 (31%)
Total carbohydrate intake (g/day)	220.23 $\pm$ 81.66**
Total carbohydrate intake (% total energy)	53,88 (29,58 – 78,73)
Total carbohydrate intake group, n(%)	
Inadequate ($\leq$77% AKG)	49 (84,5%)
Adequate (>77% AKG)	9 (15,5%)
Total fat intake (g/day)	57.74 $\pm$ 22.66**

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Total fat intake (% total energy)	32,21 ± 7,22
Total fat intake group, n(%)	
Inadequate (≤77% AKG)	27 (46,6%)
Adequate (>77% AKG)	31 (53,4%)
Fasting blood glucose (mg/dl)	86,79 ± 9,08**
Fasting insulin (mIU/dL)	6,63 (0,53 – 37,40)*
HOMA IR	1,47 (0,10 – 7,24)*

*median (min–max), ** mean ± SD

The Spearman correlation test was carried out for fiber intake and HOMA IR levels as shown in Table 2.

Table 2. Correlation between fiber intake and HOMA IR levels

Variable	HOMA IR	P value
Fiber intake	r = -0,390	0,002*

Fiber intake had a statistically significant correlation with levels of HOMA IR. Fiber intake had a negative correlation with HOMA IR (r = -0.390, p = 0.002). This suggests that an increase in fiber intake would be followed by a decrease in HOMA IR (decreased insulin resistance), and vice versa. However, the level of correlation between the two variables was classified as weak.

DISCUSSION

Characteristics of subjects

Employees who work in offices are a group at risk for insulin resistance. This is also associated with their sedentary lifestyle, where they rarely move actively during the day. In this study most of the subjects had a low level of physical activity (65.5%). These results are in line with results of research conducted by Clemes *et al*. (2014) found that physical activity was significantly lower than non-office workers. The subjects of this study had an average work-hours of 8 hours/day. Most of the activities during work were light activities. Travel from home to office and vice versa, the majority of subjects used private vehicles. Outside work hours or on holidays, very few subjects engaged in sports. In the office, there are gym facilities for exercising, but they were rarely used it. Physical activity can increase insulin sensitivity by increasing glucose transport which depends on GLUT4 in skeletal muscle. A moderate intensity exercise can increase glucose uptake by at least 40% (Qatanani *et al*., 2007). Subject's low activity decrease insulin sensitivity.

Apart from physical activity, work stress conditions and smoking status are also associated with the state of insulin resistance in employees. In this study, a small proportion of subjects were active smokers (20.7%). In accordance with previous studies on company employees in Jakarta, it was found that 71.2% of employees did not smoke (Astuti, *et al*., 2016). Another study conducted on workers showed lower levels of active smoker, namely 12.1% (Alzeidan, *et al*., 2016). In this study, as many as 91.6% of active smokers were male. Women were mostly passive smokers (Wang, *et al*., 2013), but was not studied further in this study. In a meta-analysis study, it was found that passive smoker was associated with an increased risk of insulin resistance (Wang, *et al*., 2013). The underlying mechanism was the same as with active smokers, such as the effect of nicotine interfered with insulin, damage to the pancreas due to various toxic substances in cigarettes, and the occurrence of oxidative stress, systemic inflammation, and endothelial dysfunction (Wang, *et al*., 2013).

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The subject's fiber intake had a mean value of 7.7 (2.70-37.80) grams. This number was quite low when compared to the AKG. When compared with the Adequate Intake for fiber it was still low. Adequate fiber intake at the age of 19 - 50 years is 25 g/day for women, and 38 g/day for men (Dahl, *et al*., 2015). In this study, only 3.44% had fiber intake that met the AKG. The largest sources of fiber consumed by the subjects were vegetables, fruits and whole grains such as whole wheat bread and rice. Almost all subjects in this study always ate vegetables and fruit every day, but this was not enough to meet WHO recommendations and also insufficient fiber needs based on the AKG. Based on the SKMI 2014, it was found that 95.8% of Indonesian's population in the age group of 19 - 55 consumes vegetables and fruit every day. However, only 3.1% of the population in this age group is classified as sufficient based on the recommendation of adequacy of vegetable and fruit consumption in the context of balanced nutrition. The right knowledge of the benefits of nutrition, especially vegetables and fruit, in Indonesians of all age groups still low, in adulthood only about 32 - 38%.

At the location of this study, a canteen was available, but according to the subject, the food served had a lack of taste. They often bought food from around the office or ordered food using application delivery services. The food choices they bought for lunch were lacking in fiber, such as chicken noodles, meatballs, fried chicken rice/grilled chicken. They very rarely bought fruit at the office. Furthermore, the cooking process can also affect the fiber content in food. The subjects mostly eat cooked vegetables. The process of cooking food using conventional methods or pressure cooking can reduce the amount of fiber by as much as 5- 10% (Khanum *et al*., 2000). It is recommended to eat raw vegetables, for example in salads, or cooked al dente to avoid decreasing fiber levels (Li *et al*., 2010).

The average intake of carbohydrates, fat, and energy were still below the AKG. If classified based on AKG adequacy, the majority of subjects had insufficient carbohydrate and energy intake. This was in line with Tamimi's study (2015) which showed that as many as 72% of employees of a company in Bogor had less carbohydrate intake and 78% of employees had less energy intake than the AKG. In this study, based on total energy of the subject's carbohydrate intake, the proportion of carbohydrates was within normal average limits.

Based on SKMI 2014, the age group of 19 - 55 years, the average fat consumption was 54.9 g/day. This number was not much different from the results of this study. The subject's fat intake gave an average of 32.31% of the total calories based on the percentage of fat from total calories. This composition was excessive when compared to the guidelines for balanced nutrition which recommend no more than 25% fat (Kementerian Kesehatan RI, 2014). Subjects often ate deep fried foods such as fried chicken, fried tempeh, fried bakwan, either as the main or snack food.

Correlation between fiber intake and insulin resistance

In this study, fiber intake had a negative correlation with HOMA IR (r = -0.390, p = 0.002). Increasing fiber intake followed by a decrease in HOMA IR. The lower the HOMA IR value, the higher the insulin sensitivity. These results were consistent with the results of previous studies. Cuttler *et al*. (2019) conducted a study on 137 women with PCOS and without PCOS, found a weak correlation between fiber intake and the subject's HOMA IR levels (r = -0.35, p <0.005). Weickert *et al*. (2006) conducted an RCT study on 17 subjects with a population of overweight and obesity and found improvements in total sugar levels after fiber consumption. Increasing the intake of insoluble fiber over the course of 3 days significantly increased insulin sensitivity throughout the body. Research conducted by Dong

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et al. (2019) obtained results similar to the results of this study where insufficient fiber intake was associated with increased insulin resistance as represented by HOMA IR. Hjorth *et al*. (2019) also published the results of his research that fiber intake significantly reduced the levels of HOMA IR in subjects with prediabetes.

SCFA, which is formed from bacterial fermentation of fiber in the large intestine, plays an important role in increasing insulin sensitivity (Tan *et al*., 2014). SCFA in the intestine activates GPR41, GPR43, and PPARγ. Both GPR41 and GPR43 on intestinal epithelial L-cells trigger secretion of the intestinal hormone GLP-1 which increases insulin secretion from pancreatic β cells and reduces glucagon secretion from the pancreatic islets, leading to lower glucose production from the liver and increased peripheral glucose uptake. GLP1 also suppress appetite and food intake through autonomic or central nervous system (Kim *et al*., 2017). Activation of PPARγ will increase GLUT-4 in adipocytes (Galisteo *et al*., 2008). Activation of PPAR-γ causes the release of adiponectin from mature adipocytes, which stimulates AMP involved in GLUT4 regulation in muscle, stimulation of increased fatty acid oxidation in mitochondria, and down regulation of gluconeogenesis in the liver, so the insulin sensitivity in the muscles and liver increased (Kim *et al*., 2017).

After consuming fiber, GIP will be secreted which will mediate postprandial insulin release (Kim *et al*., 2017). Several other mechanisms are that fiber reduces postprandial hyperglycemia by increasing satiety. Consuming fiber can also reduce appetite and food consumption which results in a decrease in calories (Kim *et al*., 2017). Both of these have an impact on weight loss, preventing obesity and insulin resistance (Tan *et al*., 2014).

Although there were many studies that support the results of this study, there were also studies that have different results from this study. Ostrowska *et al* (2013) conducted a study on 143 nondiabetic subjects to assess the relationship between nutritional factors and atherogenic index on insulin resistance, one of the results was that there was no relationship between fiber intake and levels of HOMA IR. Breneman et al (2011) also found no relationship between total fiber intake and levels of HOMA IR. However, when fiber intake is divided into soluble and insoluble fiber, there is a significant relationship between soluble fiber intake and levels of HOMA IR.

Many factors can influence the diversities in the results of these studies to this study. For example, the criteria for research subjects based on age and gender. It was known that age and sex would affect insulin resistance. Older age was associated with a decrease in insulin sensitivity due to an increase in adipocytes and a decrease in physical activity (Karakalides *et al*., 2010). Another explanation was that chronic inflammation tends to increase with age. Chronic inflammation impaired normal lipid accumulation, adipose tissue function, mitochondrial function, and caused stress to the endoplasmic reticulum which results in insulin resistance (Chutkan *et al*., 2012).

Furthermore, differences in study exclusion criteria such as these studies did not exclude the consumption of beta blockers, slimming drugs, carbohydrate blockers, diuretics, corticosteroids, antipsychotics, antivirals against HIV, and exclusion of pregnant and lactating women. These drugs and conditions of pregnancy and breastfeeding are confounding factors because they could affect insulin sensitivity (Chutkan *et al*., 2012, Muniyappa *et al., 2008)*.

The method of assessing fiber intake can also have an effect, for example Otruwska's study using food recall. This method relied on the subject's memory so it was easy to make mistakes when informing the food portions. This affected the total amount of intake that was being assessed.

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This study used the food record method for intake assessment, where this method was very good for measuring individual intake. In addition, the food record was very good because it avoided recall bias. When explaining to the subject about this method, the subject was given a tool to determine the portion of the food in the form of a photocopy of the food photo book from the Ministry of Health. This reduced the subject's error in determining the portion of food to be recorded.

This study had several limitations. First, it could not represent all company employees in Indonesia, because it was only conducted in a company in Jakarta. Second, this study only assessed total fiber intake but not its solubility, viscosity or fermentative properties. Specific data on fiber content that more detailed for food sources in Indonesia was still not available, making it difficult to do so. Third, the method of measuring insulin resistance was not the best method. The best method is hyperinsulinemic euglycemic glucose clamp, however, due to limited funds and time, this method could not be used in this study.

CONCLUSION

Based on the results of this study, the conclusion is that there is a negative correlation between fiber intake and insulin resistance in employees with normal weight and overweight in Jakarta. Low fiber intake can increase the occurrence of insulin resistance which results in diseases that will reduce employee productivity. We provide advice in the form of providing education to provide knowledge and increase employee awareness of the importance of consumption fiber. Companies can also provide a healthy food in the canteen, accompanied by a food composition label that provides nutritional information about the food. As well as providing various sources of fiber (example: papaya, banana, pudding, nuts, bubur manado, etc) so that employees are more interested in eating in the office canteen than buying outside. Related to physical activity, companies should schedule regular exercise and invite employees to use the available gym facilities. Furthermore, further study is needed regarding the correlation of fiber intake and insulin resistance in employees from several companies and using insulin resistance measurement in the form of hyperinsulinemic euglycemic glucose clamp.

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