Research Article

Association of dietary inflammatory index with visceral adiposity index among obese female adolescents

SUKMA CAHYANING UTAMI[1], FILLAH FITHRA DIENY[1,2*], ARYU CANDRA KUSUMASTUTI[1], A FAHMY ARIF TSANI[1]

[1] Department of Nutrition Science, Faculty of Medicine, Universitas Diponegoro, Semarang, Indonesia
[2] Center of Nutrition Resaerch, Faculty of Medicine, Universitas Diponegoro, Semarang, Indonesia
* Corresponding Author
Email ID: fillahdieny@gmail.com
Received: 13.03.20, Revised: 09.04.20, Accepted: 27.05.20

ABSTRACT

Purpose: This study aims to analyze association the dietary inflammatory index (DII) with the visceral adiposity index (VAI) in obese female adolescents.

Methodology: This study is a cross-sectional design with 87 central obesity students aged 18-21 at Universitas Diponegoro. Retrieval of the data used simple random sampling. The data that taken were weight, height, waist circumference, HDL levels, and triglyceride levels. Food intake data were obtained with the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ). The dietary inflammatory index is calculated based on 27 nutritional components, along with an overall inflammatory effect score. Negative scores indicate anti-inflammatory diets and positive scores indicate pro-inflammatory diets.Visceral adiposity index is calculated using a special formula for women with BMI components, waist circumference, HDL levels, and triglyceride levels. The data were analyzed with the Rank-Spearman test.

Results: A total of 41.4% (n = 36) subjects had a negative DII score, and 58.6% (n = 51) subjects had a positive DII score. There was a positive association between DII and VAI (p = 0.016; r = 0.259) and a negative association between DII and HDL levels (p = 0.043; r = -0.217). But there were no association between DII and BMI, waist circumference, and triglyceride levels (p> 0.05).

Keywords: DII, SQ-FFQ

INTRODUCTION

Obesity is a disorder characterized by excessive body weight due to the accumulation of fat in body tissue. Obesity occurs because of the imbalance between incoming and outgoing energy (Weni et al., 2015)(Wulandari et al., 2016). Obesity can happen to anyone, including adolescents. Adolescents are a group with a risk of obesity (Weni et al., 2015). Supported by Riskesdas 2018 data, which stated the incidence of central obesity with waist circumference> 80 cm at age ≥ 15 years was 31% in 2018. This cases had increased compared to 2013 by 26.6% (Riskesdas, 2018)(Riskesdas, 2013). Research at Iran in 2010 stated the total prevalence of central obesity was 32.01% and was significantly higher in women as much as 57.2% compared to men as much as 15.8% (Veghari et al., 2010).

Obesity has a negative impact on adolescent health, so it must be handled early. Nearly 90% of obese children and adolescents had at least one of the characteristics of metabolic syndrome. The condition of obesity is called an inflammatory reaction due to the accumulation of fat tissue or adipose cells that fill the empty cavities in the body, especially in the cavity in the abdominal region, so it is called visceral fat or known as central obesity. Obesity, especially abdominal or visceral obesity, is associated with increased of adipocytokine production, pro-inflammatory activity, decreased of insulin sensitivity, increased risk of diabetes, dyslipidemia (high triglycerides and low HDL), hypertension, atherosclerosis, and higher mortality rates (Amato et al., 2010).

Visceral adipose tissue manifests as a true endocrine organ with important secretions of adipokines and vasoactive substances that affect the risk of developing or worsening the metabolic disease (Gargavu et al., 2018). Researchers have developed visceral adipose indicators with higher sensitivity and specificity than commonly used parameters such as waist circumference, BMI, and fat. Researchers developed the visceral adiposity index (VAI) using formulas with parameters such as waist circumference, BMI, triglycerides, and HDL (Amato et al., 2010).

$$VAI = [(waist\ circumference / 36.58) + (1.89 \times BMI) \times (triglycerides / 0.81) \times (1.52 / HDL)] \quad (1)$$

This formula can make VAI being an easy tool for evaluating cardio-metabolic risk because it can

show increased adipose tissue (Gargavu et al., 2018).

Many factors can be associated with obesity. One of the factors that have a huge influence is nutrient intake (Islami et al., 2016). Research that conducted by Kartika S and Siti Rahayu N in 2015 resulted in at the level of fat consumption, 90% of the obese group have an excessive level of consumption (Suryaputra Kartika, 2012). Recently, many studies are discussing foods that have the potential to increase inflammation. Adolescent is a group that is vulnerable to malnutrition. Current adolescent practical eating habits make it difficult to avoid fast foods that contain lots of calories, fat and cholesterol (Wulandari et al., 2016). As known, saturated fatty acid and food that have a high glycemic index is a pro-inflammatory source (Steck, 2014).

A study stated the frequency of junk food consumption in overweight and obese girls who were boarders (*indekos*) based on interview is high. Consumption of junk food with a frequency of 1-2 times a week classified into a high category (Septiana, et al., 2018). Some studies revealed that diets with pro-inflammatory foods have a high dietary inflammatory index (DII) value significantly associated with an increased of CRP, risk of cardiovascular disease, and increased metabolic syndrome (Neufcourt et al., 2015)(Nikniaz L, et al., 2018)(Wirth et al., 2015)(Ramallal et al., 2015). On the other hand, the intake of anti-inflammatory sources in adolescents is still in lack, as in the case of Pipit et al., which showed that the average intake of adolescent's fiber only reached 3.91 grams. This reflects the intake of fiber in adolescents is still very low when it compared to the adequacy of the FDA which is 25grams/day (Septiana et al., 2018). A study mentioned a Mediterranean diet that is rich in grains, fish, fruit, and green vegetables, moderate alcohol and olive oil and low consumption of red meat and butter had been associated to lower levels of inflammation (Cavicchia et al., 2009).

Researchers have developed an instrument of eating habits with food-related pro-inflammatory and anti-inflammatory sources to various chronic diseases using the dietary inflammatory index (DII). DII is an index used to measure how potential food can cause inflammation in the body. DII can estimate the inflammatory potential from a person's diet through a meal frequency questionnaire (SQ-FFQ), and the result of DII inform the quality of diet including the pro-inflammatory or anti-inflammatory diet (Y. Kim et al., 2018). As known, to increase the intake of healthy and anti-inflammatory foods such as fruits, vegetables and reduce the intake of pro-inflammatory components such as processed meat and sugary drinks is good because it can play an essential role in reducing the risk of cardiovascular disease and related mortality (Shivappa et al., 2018).

There is a lack of research on DII in Indonesia. So, based on the background of the problems that have been described, the researcher intends to analyze how the DII profile and its association with the increase of VAI in female adolescents.

METHODS

This research was carried out in June - August 2019 with the subject of female students from several faculty of Universitas Diponegoro, Tembalang, Semarang City. This research is an observational study with a cross-sectional design. Subject selection began with a screening process obtained 1260 subjects, then 215 subjects entered the inclusion criteria, and 87 subjects were selected that fulfill the criteria with a simple random sampling method. Inclusion criteria in this study were Universitas Diponegoro students aged 18-21 years, had a waist circumference ≥ 80 cm, did not in pregnant and breastfeeding period, did not smoke and in alcohol consumption, did not take drugs that could affect cholesterol levels, and were willing to fill out forms as a research subject. The exclusion criteria in this study were the subject that resigns from this study, became ill, died, and moved to another university.

The dependent variable in this study is the dietary inflammatory index (DII). While the independent variable in this study is the visceral adiposity index (VAI) with several components, including BMI, waist circumference, HDL, and triglycerides. For the confounding variable is physical activity, measured with the International Physical Activity Questionnaire (IPAQ) which divided into three categories: low (<600 MET/minute/ week), moderate (600-2999 MET/minute/ week), high (≥3000 MET/minute/ week) (Ipaq, 2005).

The dietary inflammatory index is an index used to measure how potential the food can cause inflammation in the body. Briefly, the researchers' history found DII scores derived from grading algorithms based on various articles published from 1950 to 2010 that evaluated the effects of diet on six inflammatory biomarkers. Articles that qualified will be assessed for each dietary parameter if increasing the inflammation is given +1, if decreasing the inflammation is given -1, and if it has no effect it is given 0.15 DII can estimate the inflammation potential from a person's diet as measured using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) form which then will be analyzed using the

Nutrisurvey 2007 computer program and calculated by multiplying the overall inflammatory effect score, the total value of DII can inform the quality of the pro-inflammatory or anti-inflammatory diet (Y. Kim et al., 2018). Negative scores indicate anti-inflammatory diets and positive scores indicate pro-inflammatory diets (Cavicchia et al., 2009).

Visceral adiposity index is an index used in clinical practice to assess cardiometabolic risk associated with visceral obesity (Gargavu et al., 2018). How to determine the results of the visceral adiposity index by anthropometric measurements (body weight, height, and waist circumference), measurement of HDL, and triglyceride levels. Weight was measured using TANITA brand digital weight scales with an accuracy of 0.1 kg. Height is measured using a microtoise with an accuracy of 0.1 cm. Waist circumference is measured using a metline in cm and has 2 categories: normal (<80 cm) and central obesity (≥80 cm). Body mass index (BMI) is a nutritional status assessment obtained through the distribution of weight measurements (kg) by the quadratic of height (meters), that consists of 5 categories which are underweight (BMI <18.5 kg/m^2), normal (BMI 18.5-22.9 kg/m^2), overweight (BMI 23-24.9 kg/m^2), and obese (BMI ≥25 kg/m^2) (Pan & Ms, 2008).

While taking blood samples to measure levels of HDL and triglycerides in the subject is done by a laboratory officer. Five mL of blood was taken, and before it, the subject should be fasting for at least 8 hours. Blood sample check resulted in the levels of HDL and triglycerides in mg/dL, which will be converted into mmol/L by multiplying respectively 0.0259 and 0.0113. The results of anthropometric data measurements, HDL levels and triglyceride levels were included in the equation for the VAI formula specifically for women ((waist circumference / 36.58 + (1.89 x IMT) x (triglyceride / 0.81) x (1.52 / HDL)). The cut-off point of the visceral adiposity index for age <30 years is ≤ 2,52 (Amato et al., 2011).

Univariate analysis was performed to describe the characteristics of the subject; the variables in this study were DII as the independent variable and VAI as the dependent variable. The data normality test used was Kolmogorov-Smirnov. The bivariate analysis used the Spearman Rank test for abnormally distributed data. The purpose of the bivariate analysis is to look at the association between DII and VAI in obese female adolescents at Universitas Diponegoro.

RESULTS

Subject Characteristics

The results of screening on 1260 female students aged 18-21 years. After inclusion and exclusion criteria, total subjects involved until the end of the study were 87 subjects. Subject characteristics in this study include general subject data, anthropometric data, DII, VAI, along with its components and physical activity scores can be seen in Table 1.

Table 1: Characteristic of the subjects

Characteristic	Min.	Max.	Mean±SD/Median
Age (year)	18.0	21.0	19.8 [a]
Weight (Kg)	47.8	107.4	65.8[a]
(cm)	141.2	171.4	157.35±5.25[b]
VAI (score)	0.64	6.8	1.4[a]
BMI (kg/m^2)	21.13	41.82	26.65[a]
Waist circumference (cm)	80.2	114	85[a]
HDL (mmol/L)	0.73	1.92	1.33±0.25[b]
Triglyseride (mmol/L)	0.49	2.87	0.98[a]
Physical activity score (MET/min/week)	35	1305	237[a]
DII (total score)	-907.58	385.89	26.42[a]
Pro-inflammation (score)	110.27	968.61	395.08 [a]
Anti-inflammation (score)	-1617.8	-82.21	-321.31 [a]
Pro-inflammation component			
Energy (kcal)	88.81	752.74	304.9 [a]
Carbohydrate (g)	5.17	48.68	22.03±8.99 [b]
Fat (g)	5.13	72.29	19.97 [a]
Protein (g)	0.22	3.05	1.1[a]
Cholesterol (mg)	3.18	98.23	22.39 [a]
Vitamin B12 (μg)	0.02	1.76	0.18 [a]
Saturated fatty acid (g)	2.35	58	13.32 [a]

Characteristic	Min.	Max.	Mean±SD/Median
Trans fat (g)	0.0	1.69	0.53 [a]
Iron (mg)	0.04	1.23	0.21 [a]
Anti-inflammation component			
Fiber (g)	-27.85	-1.59	-5.37 [a]
Vitamin B6 (mg)	-1.13	-0.11	-0.33 [a]
Omega 3 (g)	-1	0.0	-0.4 [a]
Omega 6 (g)	-2.53	0.0	-0.3 [a]
MUFA (g)	-0.48	-0.02	-0.12 [a]
PUFA (g)	-15.97	-0.37	-2.33 [a]
Vitamin B2 (mg)	-0.14	-0.01	-0.4 [a]
Vitamin B1(mg)	-0.22	-0.01	-0.04 [a]
Vitamin B3 (mg)	-5.54	-0.49	-2.18±0.99 [b]
Magnesium (mg)	-337.18	-26.04	-88.09 [a]
Zinc (mg)	-5.2	-0.19	-1.57 [a]
Selenium (μg)	-61.31	-4	-19.61 [a]
Vitamin C (mg)	-287.9	-1.53	-20.56 [a]
Vitamin D (μg)	-4.15	0.0	-0.58 [a]
Vitamin E (mg)	-5.07	0.0	-0.88 [a]
Folic (μg)	-92.97	-0.4	-20.94 [a]
Caffeine (g)	-21.23	0.0	-0.29 [a]
Vitamin A (RE)	-1286	-5.85	-160.4 [a]

[a]Median, [b]Mean±SD

The results in Table 1 show that the mean age of the subjects was 19 years eight months, with the total of the subject is 87. The mean body weight of the subject is 65.8 kg, and the mean body height of the subject is 157.35 cm. The minimum value of the subject's waist circumference was 80.2 cm, indicating that all subjects have one of the markers of metabolic syndrome, ie, waist circumference ≥80 cm. When using the BMI indicator, it had a mean value of 26.5 kg/m^2, so the subject was dominated by the obesity category. DII had a mean value of 26.42, this explains that the subjects dominantly consume a pro-inflammatory diet. Pro-inflammatory and anti-inflammatory had median values of 395.08 and -321.31. Many subjects had VAI in the normal category because it had a value of 1.4 (≤2.52). Meanwhile, for the mean HDL levels and the median value of triglyceride levels were 1.33 mmol / L and 0.98 mmol / L, which included in the normal category. The median value of the physical activity of the subject is 237 MET/minute/ week, and this explains that the subject mostly only doing light activities, not even a subject doing strenuous activities in the last week when data collection.

Table 2: Categories of Subject Characteristics by Age, Body Weight, Height, Dietary Inflammatory Index Score, Visceral Adiposity Index Score, and Its Components and Physical Activity Scores

Characteristic	n	%
Age		
18-21 year old	87	100
DII		
Anti-inflammation	36	41.4
Pro-inflammation	51	58.6
VAI		
Normal	81	93.1
High	6	6.9
Nutritional status based on BMI		
Normal	13	14.9
Overweight	17	19.5
Obese	57	65.5
Waist circumference		
Central obesity	87	100
HDL levels		
Low	11	12.6

Characteristic	n	%
High	76	87.4
Triglyceride level		
Low	82	94.3
High	5	5.7
Physical activity		
Low	74	85.1
Moderate	13	14.9

Table 2 shows that the 87 subjects who had a negative DII (anti-inflammatory diet) were 41.4%, but 58.6% of the subjects had a positive DII (pro-inflammatory diet). Subjects who had normal VAI were 93.1%, and 6.9% of subjects had a high VAI. The categories for VAI components, such as the nutritional status of subjects based on BMI are dominated by the nutritional status of obesity with BMI> 25 kg / m2 as much as 65.5%.

On the other hand, subjects who had overweight nutritional status were 19.5%, and normal nutritional status was 14.9%. For waist circumference, 100% of subjects experienced central obesity (≥80 cm). Subjects who had low HDL levels were 12.6%, and high HDL levels were 87.4%. While for subjects who have low triglyceride levels were 94.3% and high triglyceride levels were 5.7%. For physical activity, the subject was dominated by the low category by 85.1% and the medium category by only 14.9%.

Association between DII and Confounding Variables with VAI and its Components (BMI, Waist Circumference, HDL Levels and Triglyceride Levels)

Table 3 shows that the DII variable (r = 0.259; p = 0.016) is positively related to VAI. The higher the DII, the higher the VAI. The DII variable (r = -0.217; p = 0.043) is negatively related to HDL levels. The higher the DII, the lower the HDL level.

Table 3: Association between DII scores and physical activity scores with VAI, BMI, waist circumference, HDL, triglycerides

Variable	VAI		BMI		WC		HDL		TG	
	r^a	p^a	r^a	p^a	r^a	p^a	r^a	p^a	r^a	p^a
DII	0.259	0.016*	0.136	0.208	0.124	0.252	-0.217	0.043*	0.163	0.132
Physical activity	0.104	0.337	0.065	0.547	-0.060	0.580	0.073	0.504	0.199	0.065

[a]*Rank-Spearman*; *Significantly associated (p<0,05)

DISCUSSION

The number of subjects in female students aged 18-21 at Universitas Diponegoro was 87 people. Using a waist circumference indicator, 17% of Universitas Diponegoro students had central obesity. This result is higher than the results of the 2013 Central Java Province Basic Health Research showing the prevalence of central obesity in the age group of 15-24 years by 9.5%. The prevalence of central obesity is higher in women by 39.4 % (Riskesdas, 2013). However, this prevalence is lower when compared to national surveys that the prevalence of central obesity in women is 41.9%(Harbuwono et al., 2018).

Central obesity is often called the visceral type due to excessive accumulation of fat and far beyond normal in the abdomen.(Ticoalu, et al. 2015) Visceral fat itself is the body fat that collected in the central part of the body and covered the internal organs. Excess visceral fat is closely related to the occurrence of degenerative diseases and the incidence of metabolic syndrome (Tatsumi et al., 2017).

Adipose tissue is a tissue that plays a role in the release of free fat, pro-, and anti-inflammatory cytokines, so obese individuals tend to experience homeostatic cholesterol disorders, such as high triglyceride levels and low HDL levels.(Taverne, et al., 2013) In this study, some subjects experienced hypertriglyceridemia by 5.7 % and subjects who had low HDL levels by 12.6%. At present, there is a visceral adipose indicator called VAI with higher sensitivity and specificity than commonly used parameters such as waist circumference, BMI, and fat.(Amato et al., 2010) The VAI formula requires data related to BMI, waist circumference, HDL levels, and triglyceride

levels. VAI is significantly associated with adipocytokine synthesis, pro-inflammatory activity, and dyslipidemia (Garcés et al., 2014). In this study, subjects had high VAI values by 14.4%.

Increased incidence of central obesity and several observations of other metabolic syndromes in adolescents occur due to several factors such as excessive food intake, consumption of fatty foods, consumption of fast food, and low physical activity or sedentary lifestyles (Mardiana & Prameswari, 2013). Current eating habits of adolescents that prefer fast food which contain pro-inflammatory nutritional sources (Kord Varkaneh et al., 2018). Subjects in this study were 58.6% had high DII; this indicated that more subjects consumed pro-inflammatory diets than subjects with low DII by 41.4% or who consumed anti-inflammatory diets.

A high DII reflects a pro-inflammatory diet, while a low DII reflects an anti-inflammatory diet. A study mentioned that the increase in DII or high consumption of pro-inflammatory diets cause an increase in obesity. The pro-inflammatory diet itself can contribute more to the markers of inflammation and weight gain.(Kord Varkaneh et al., 2018).

Physical activity is closely related to the incidence of central obesity, because routine physical activity can help encourage decrease in fat tissue, even without weight loss (Andre & Despres, 2013). This study was dominated by subjects who had low physical activity of 85.1%, and subjects with moderate physical activity by 14.9% Most subjects spend time with only sitting and rarely do sports. Inactive lifestyles and low activity levels are one of the causes of obesity (Elisabeth et al., 2013).

The Association Between Dietary Inflammatory Index Score With Visceral Adiposity Index Score and Its Components

The correlation test showed there was a significant association between DII with VAI ($p = 0.016$) and HDL levels ($p = 0.043$) in adolescents. This finding is consistent with research on female subjects in Johannesburg, Africa revealed that visceral fat measurements are higher in subjects with high DII (pro-inflammatory) compared with subjects who had low DII (anti-inflammatory).(Asanda et al., 2019) These results proved that consuming an excessive pro-inflammatory diet can increase total fat accumulation and the incidence of central obesity (Weisberg et al., 2003)(C. Kim et al., 2006)(Snel et al., 2012). In DII, there are 9 of 27 components of nutrients, which are a source of pro-inflammatory energy, carbohydrates, fats, proteins, cholesterol, vitamin B12, saturated fatty acids, trans fat, and iron.

Food sources that trigger high inflammation are processed starches, sugars, saturated fatty acids, trans fat, and low omega 3 fatty acids, natural antioxidants such as fiber from fruits, vegetables, and grains (Glaser, 2010). A high-fat diet causes excessive accumulation of body fat and damages the immune system. Several fatty acids, such as polyunsaturated acids (PUFAs), saturated fatty acids, and trans fatty acids, have a significant effect on inflammatory status (Joffe et al., 2013). Carbohydrates with a relatively high glycemic index (GI) and glycemic load (GL) have also been associated with increased risk of coronary heart disease, stroke, and type 2 diabetes mellitus, especially among overweight individuals (Galland, 2018). High GI and GL diets are significantly associated with biomarkers/markers of inflammation (Lee et al., 2013).

A study of western-type diets that tend to reflect pro-inflammatory diets such as high red meat and high-fat dairy products are associated with inflammatory markers such as CRP levels, interleukin IL-6, and higher fibrinogen (Johansson-Persson et al., 2014). The condition of obesity is associated with various disorders, including disorders of the adipokine reaction that trigger the low-level inflammation. One factor that can activate the inflammatory reaction is pro-inflammatory food sources such as fat intake, especially saturated fatty acids, and cholesterol. The amount of saturated fat intake and cholesterol intake contribute to the development of low-level inflammation associated with metabolic disorders (Rachmawati & Sulchan, 2014).

So the importance of daily consumption of anti-inflammatory food sources, such as vegetables and fruit. The antioxidant character of vegetables and fruits are considered as one of the mechanisms underlying the contribution of the anti-inflammatory diet. Higher vegetable and fruit intake are associated with lower oxidative stress and inflammation. The addition of antioxidants or vegetables can limit or reverse the pro-inflammatory response of foods that high in saturated fatty acids (Glaser, 2010)(Calder et al., 2009). Choosing a good diet such as proper consumption of GI and GL, PUFA, low trans-fat, high vitamins, and minerals is necessary to reduce the presence of inflammation (Joffe et al., 2013).

High DII can be associated with any sign of metabolic syndrome, such as low HDL levels (Neufcourt et al., 2015)(Nikniaz et al., 2018)(Wirth et al., 2015)(Ramallal et al., 2015). This is consistent with research in subjects aged

18-69 years in Luxembourg which mentioned that subjects with high DII had lower HDL levels compared to subjects who had a low DII (Alkerwi et al., 2014). Pro-inflammatory diets such as high consumption of fatty acids will affect adipose tissue especially visceral fat to express responses to various stimuli, one of them is an increase in the release of free fatty acids by adipose tissue which could stimulate the increase of VLDL secretion in the liver which will resulted in increase in triglycerides and decrease in HDL (Gropper et al., 2009; Wang & Peng, 2011). That increase will trigger the release of HDL from the liver to carry cholesterol in the circulation (reverse cholesterol transport). This HDL is esterified into cholesterol esters, which can be directly carried to the liver to be directly excreted or exchanged with triglycerides from VLDL and chylomicrons. When cholesterol esters are excessive, triglyceride-rich HDL (low-density HDL) is broken down by hepatic lipase, thereby reducing HDL levels (Barasi, 2009; Barasi, 2009).

An anti-inflammatory source nutrient that works to increase HDL levels, one of them is vitamin C. Vitamin C (ascorbic acid is an antioxidant that can affect the lipid profile). This is evidenced from the intervention research on the administration of aloe vera juice containing vitamin C with the results of the increase in HDL levels in 2 groups of subjects, although statistically, the increase in HDL levels was not significant (Utami & Kusumastuti, 2014). The fiber is also a source that can increase HDL levels. This is supported by cross-sectional studies that found increased fiber intake was significantly associated with increased HDL levels (Zhou et al., 2015).

In this study there was no significant association between DII and BMI ($p = 0.208$), waist circumference ($p = 0.252$) and triglyceride levels ($p = 0.132$). This is consistent with research on subjects aged 19-56 years in Yogyakarta, which stated that there is no association with triglyceride levels (Muhammad et al., 2019). In contrast to the studies of Neufcourt et al. showed that high DII or pro-inflammation is significantly associated with high triglyceride levels and lower HDL levels (Neufcourt et al., 2015). So that this study cannot confirm that DII is associated with triglyceride levels.

In this study, there was no significant association between physical activity with VAI, BMI, waist circumference, HDL levels, and triglyceride levels in adolescents. This is maybe because most subjects spend more time in college by sitting in class, and only lying while playing gadgets when the subject is at boarding/at home. Most of the subjects admitted that they rarely did sports because their time was occupied with doing college assignments. So that the type, frequency, and intensity of physical activity undertaken by the subject cannot describe the relationship of physical activity with VAI and its components in adolescents. These results are consistent with research on adolescents in Manado at 2012 that there was no significant association between physical activity and waist circumference in adolescents (Elisabeth et al., 2013).

CONCLUSION

Most of the subjects in this study had the habit of consuming pro-inflammatory diets by 58.6%. The higher the DII, the higher the VAI and lower for HDL levels. 6.9 % of subjects had high VAI, and 12.6% of subjects had low HDL levels. There was a positive association between DII and VAI) and a negative association between DII and HDL levels.

ETHICS CLEARANCE

This study was approved by the Sultan Agung Islamic Hospital Ethics Commission No. 54/B/RSI-SA/X/2019.

SUGGESTION

A high DII score or a pro-inflammatory diet is significantly associated with obesity. So that students need to get an education and counselling about selecting food sources. Pro-inflammatory food sources such as junk food, innards, fried foods, etc. Anti-inflammatory food sources such as vegetables, fruit, fish, and others. We hope it can reduce the accumulation of visceral fat or the incidence of central obesity by modifying food source choices without reducing intake requirements.

ACKNOWLEDGMENTS

This research was funded by the The Ministry of Research, Technology and Higher Education 2019, Indonesia.

REFERENCES

1. Alkerwi, A., Shivappa, N., Crichton, G., & Hebert, J. R. (2014). No Significant Independent Relationships with Cardiometabolic Biomarkers were Detected in the Observation of Cardiovascular Risk Factors in Luxembourg Study Population. *Nutr Res*, *34*(12), 1058–1065. https://doi.org/10.1016/j.nutres.2014.07.017.No
2. Amato, M. C., Giordano, C., Galia, M., Criscimanna, A., Vitabile, S., Midiri, M., & Galluzzo, A. (2010). Visceral Adiposity Index: A Reliable Indicator Of Visceral Fat Function Associated With Cardiometabolic Risk. *Diabetes Care*, *33*(4), 920–922. https://doi.org/10.2337/dc09-1825
3. Amato, M. C., Giordano, C., Pitrone, M., &

Galluzzo, A. (2011). Cut-Off Points Of The Visceral Adiposity Index (VAI) Identifying A Visceral Adipose Dysfunction Associated With Cardiometabolic Risk In A Caucasian Sicilian Population. *Lipids in Health and Disease*, *10*, 1–8. https://doi.org/10.1186/1476-511X-10-183

4. Andre, T., & Despres, J. (2013). Pathophysiology of Human Visceral Obesity: An Update. *Physol Rev*, *93*, 359–404. https://doi.org/10.1152/physrev.00033.2011
5. Asanda, M., Micklesfield, L. K., Chorell, E., Olsson, T., Shivappa, N., Rebert, J. R., Goedecke, J. H. (2019). Adiposity Mediates the Association between the Dietary Inflammatory Index and Markers of Type 2 Diabetes Risk in Middle-Aged Black South African Women. *Nutrients*, *11*, 1–19.
6. Barasi, M. E. (2009). At a Glance Ilmu Gizi. Jakarta: Erlangga.
7. Calder, P. C., Albers, R., Antoine, J., Blum, S., Ferns, G. A., & Folkerts, G. (2009). Inflammatory Disease Processes and Interactions with Nutrition. *British Journal of Nutrition*, *101*, S1-45.
8. Cavicchia, P. P., Steck, S. E., Hurley, T. G., Hussey, J. R., Ma, Y., Ockene, I. S., & He, J. R. (2009). A New Dietary Inflammatory Index Predicts Interval Changes in Serum High-Sensitivity C-Reactive Protein1–3. *J Nutr*, *139*, 2365–2372. https://doi.org/10.3945/jn.109.114025.2365
9. Elisabeth, T. M., Tanudjaja, G. N., & Kalangi, S. J. (2013). Hubungan Antara Ativitas Fisik dengan Lingkar Pinggang pada Siswa Obes Sentral. *E-Biomedik*, *1*(1), 455–460.
10. Galland, L. (2018). Diet and Inflammation. *Nutrition in Clinical Practice*, *25*(6), 634–640. https://doi.org/10.1177/0884533610385703
11. Garcés, M. J., Hernández, J., Queipo, G., Klünder-Klünder, M., Bustos, M., Herrera, A., Garibay, N. (2014). Novel Gender-Specific Visceral Adiposity Index For Mexican Pediatric Population. *Revista Médica Del Hospital General De México*, *77*(4), 153–159. https://doi.org/10.1016/j.hgmx.2014.10.002
12. Gargavu, S. R., Clenciu, D., Rosu, M. M., Tenea Cojan, T. S., Costache, A., Vladu, I. M., & Mota, M. (2018). Visceral Adiposity Index (Vai) – a Potential Marker of Cardiometabolic Risk. *Archives of the Balkan Medical Union*, *53*(2), 246–251. https://doi.org/10.31688/abmu.2018.53.2.11
13. Glaser, J. K. K. (2010). Stress, Food and Inflammation: Psychoneuroimmunology and Nutrition at The Cutting Edge. *Pshychosom Med*, *72*(4), 365–369. https://doi.org/10.1097/PSY.0b013e3181dbf489.Stress
14. Gropper, S. S., Smith, J. K., & Groff, J. L. (2009). Advanced Nutrition and Human Metabolism (5th ed.). USA: Wadsworth.
15. Harbuwono, D. S., Pramono, L. A., Yunir, E., & Subekti, I. (2018). Obesity And Central Obesity In Indonesia : Evidence From A National Health Survey. *Department of Internal Medicine, Faculty of Medicine Universitas Indonesia*, *27*(2), 114–120.
16. Ipaq. (2005). Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ) – Short and Long Forms. 1–15.
17. Islami, N., Hanifah, D., & Dieny, F. F. (2016). Hubungan Total Asupan Serat, Serat Larut Air (Soluble), Dan Serat Tidak Larut Air (Insoluble) dengan Kejadian Sindrom Metabolik Pada Remaja Obesitas. *JNC*, *5*(Jilid 2), 148–155.
18. Joffe, Y. T., Collins, M., & Goedecke, J. H. (2013). The Relationship between Dietary Fatty Acids and Inflammatory Genes on the Obese Phenotype and Serum Lipids. *Nutrients*, *5*, 1672–1705. https://doi.org/10.3390/nu5051672
19. Johansson-Persson, A., Ulmius, M., Cloetens, L., Karhu, T., Herzig, K. H., & Önning, G. (2014). A High Intake of Dietary Fiber Influences C-reactive Protein and Fibrinogen, but Not Glucose and Lipid Metabolism, in Mildly Hypercholesterolemic Subjects. *European Journal of Nutrition*, *53*(1), 39–48. https://doi.org/10.1007/s00394-013-0496-8
20. Kim, C., Park, H., Kawada, T., Kim, J., Lim, D., Hubbard, N. E., Yu, R. (2006). Circulating Levels Of MCP-1 And IL-8 Are Elevated In Human Obese Subjects And Associated With Obesity-Related Parameters. *Int. J. Obes*, *6*, 1347–1355. https://doi.org/10.1038/sj.ijo.0803259
21. Kim, Y., Chen, J., Wirth, M. D., Shivappa, N., & Hebert, J. R. (2018). Lower Dietary Inflammatory Index Scores Are Associated With Lower Glycemic Index Scores Among College Students. *Nutrients*, *10*(2), 1–12. https://doi.org/10.3390/nu10020182
22. Kord Varkaneh, H., Fatahi, S., Tajik, S., Rahmani, J., Zarezadeh, M., & Shab-Bidar, S. (2018). Dietary Inflammatory Index In Relation To Obesity And Body Mass Index: A Meta-Analysis. *Nutrition and Food Science*, *48*(5), 702–721. https://doi.org/10.1108/NFS-09-2017-0203
23. Lee, H., Lee, I. S., & Choue, R. (2013). Obesity, Inflammation and Diet. *Pediatric Gastroenterology, Hepatology & Nutrition*, *16*(3), 143–152.
24. Mardiana, L., & Prameswari, G. (2013). Obesitas Sentral dan Kadar Kolesterol Total. *Kesehatan Masyarakat*, *9*(1), 37–43.
25. Muhammad, H. F. L., Baak, M. A., Mariman, E. C., Sulistryoningrum, D. C., Huriyati, E., Lee, Y. Y., & Muda, W. A. M. W. (2019). Dietary Inflammatory Index Score and Its Association with Body Weight, Blood Pressure, Lipid Profile, and Leptin in Indonesian Adults. *Nutrients*, *11*(148), 1–11. https://doi.org/10.3390/nu11010148
26. Neufcourt, L., Assmann, K. E., Fezeu, L. K., Touvier, M., Graffouillère, L., Shivappa, N., Kesse-Guyot, E. (2015). Prospective association

between the dietary inflammatory index and metabolic syndrome: Findings from the SU.VI.MAX study. *Nutrition, Metabolism and Cardiovascular Diseases*, *25*(11), 988–996. https://doi.org/10.1016/j.numecd.2015.09.002

27. Nikniaz, L., Nikniaz, Z., Shivappa, N., & Hébert, J. R. (2018). The Association Between Dietary Inflammatory Index and Metabolic Syndrome Components In Iranian Adults. *Primary Care Diabetes*, *12*(5), 467–472. https://doi.org/10.1016/j.pcd.2018.07.008
28. Pan, W., & Ms, W. Y. (2008). How To Define Obesity ? Evidence-Based Multiple Action Points For Public Awareness , Screening , And Treatment : An Extension Of Asian-Pacific Recommendations. *Asia Pac J Clin Nutr*, 17(3), 370–374.
29. Rachmawati, S., & Sulchan, M. (2014). Asupan Lemak dan Kadar High Density Lipoprotein (HDL) Sebagai Faktor Risiko Peningkatan Kadar C-Reactive Protein (CRP) Pada Remaja Obesitas dengan Sindrom Metabolik. *Journal of Nutritional College*, *3*(3), 337–345.
30. Ramallal, R., Estefania, T., Hernandez, M. A. M. G. A. H., Arellano, A. G., Shivappa, N., Hebert, J. R., & Ruiz, M. (2015). Dietary Inflammatory Index And Incidence Of Cardiovascular Disease In The PREDIMED Study. *Plos One*, *7*(6), 4124–4138. https://doi.org/10.3390/nu7064124
31. Riskesdas. (2013). Riset Kesehatan Dasar. *Badan Penelitian Dan Pengembangan Kesehatan Kementerian Kesehatan RI*.
32. Riskesdas. (2018). Hasil Utama Riskesdas. *Badan Penelitian Dan Pengembangan Kesehatan Kementerian Kesehatan RI*.
33. Septiana, P., Nugroho, F. A., & Wilujeng, C. S. (2018). Konsumsi Junk food dan Serat pada Remaja Putri Overweight dan Obesitas yang Indekos. *Jurnal Kedokteran Brawijaya*, *30*(1), 61. https://doi.org/10.21776/ub.jkb.2018.030.01.11
34. Shivappa, N., Godos, J., Hébert, J. R., Wirth, M. D., Piuri, G., Speciani, A. F., & Grosso, G. (2018). Dietary Inflammatory Index And Cardiovascular Risk And Mortality—A Meta-Analysis. *Nutrients*, *10*(2), 1–15. https://doi.org/10.3390/nu10020200
35. Snel, M., Jonker, J. T., Schoones, J., Lamb, H., Roos, A. De, Pijl, H., Jazet, I. M. (2012). Ectopic Fat and Insulin Resistance : Pathophysiology and Effect of Diet and Lifestyle Interventions. *Int. j. Endocrinol*, *2012*, 1–18. https://doi.org/10.1155/2012/983814
36. Steck, S. (2014). The Dietary Inflammatory Index and Risk of Colorectal and Breast Cancers in The Women's Health Initiative. *Epidemiology and Biostatistics Cancer Prevention and Control Program Arnold School Og Public Health University of South Carolina*.
37. Suryaputra K., Nadhiroh S. R. (2012). Perbedaan Pola Makan Dan Aktivitas Fisik Antara Remaja Obesitas dengan Non Obesitas. *Makara Kesehatan*, *16*(1), 45–50.
38. Tatsumi, Y., Nakao, Y. M., Masuda, I., Higashiyama, A., Takegami, M., Nishimura, K., Miyamoto, Y. (2017). Risk For Metabolic Diseases In Normal Weight Individuals With Visceral Fat Accumulation : A Cross-Sectional Study In Japan. *BMJ Open*, 1–8. https://doi.org/10.1136/bmjopen-2016-013831
39. Taverne, F., Richard, C., & Couture, P. (2013). Abdominal Obesity , Insulin Resistance , Metabolic Syndrome And Cholesterol Homeostasis. *PharmaNutrition*, 1-7. https://doi.org/10.1016/j.phanu.2013.07.003
40. Ticoalu, M. A. C., Wongkar Djon, Pasiak T. F. (2015). Angka Kejadian Obesitas Sentral Pada Wanita di Desa Tumaluntung. Jurnal e-Biomedik, *3*(1), 528-531.
41. Utami, R. W., & Kusumastuti, A. C. (2014). Pengaruh Vitamin C Terhadap Kadar High Density Lipoprotein (Hdl) Lanjut Usia Setelah Pemberian Jus Lidah Buaya (Aloe barbadensis Miller). *Journal of Nutritional College*, *3*(4), 737–744.
42. Veghari, G., Sedaghat, M., Joshaghani, H., Hoseini, A., Niknajad, F., Angizeh, A., Moharloei, P. (2010). The Prevalence and Associated Factors of Central Obesity in Northern Iran. *Iranian Cardiovaskular Research Journal*, *4*(4), 164–168.
43. Wang, H., & Peng, D. (2011). New Insights into The Mechanism of Low High Density Lipoprotein Cholesterol in Obesity. *Lipids in Health and Disease*, *10*(1), 176. https://doi.org/10.1186/1476-511X-10-176
44. Weisberg, S. P., Mccann, D., Desai, M., Rosenbaum, M., Leibel, R. L., & Ferrante, A. W. (2003). Obesity is Associated with Macrophage Accumulation in Adipose Tissue. *J. Clin. Invest.*, *112*, 1796–1808. https://doi.org/10.1172/JCI200319246.
45. Weni, K., Suryani, I., Syamsiatun, N. H., Siwi, L. P., Adityanti, M. M., Mustikaningsih, D., & Sholihah, K. I. (2015). Risk Factors For Obesity In Adolescent. *Jurnal Gizi Klinik Indonesia*, *11*(4), 179–190. https://doi.org/10.22146/ijcn.22900
46. Wirth, M., James, B., Nitin, S., John, M. V., Burchfiel, C. M., Desta, F., Mnatsakanova, A. (2015). Association of a Dietary Inflammatory Index with Inflammatory Indices and the Metabolic Syndrome among Police Officers. *J Occup Environ Med*, *56*(9), 986–989. https://doi.org/10.1002/jmri.25711.PET/MRI
47. Wulandari, S., Hariati, L., & Andi, F. F. (2016). Faktor yang Berhubungan dengan Kejadian Obesitas pada Remaja di SMA Negeri 4 Kendari Tahun 2016. *Fakultas Kesehatan Masyarakat Universitas Halu Oleo*, 1–13. Retrieved from https://media.neliti.com/media/publications/186655-ID-faktor-yang-berhubungan-dengan-kejadian.pdf