ISSN No:-2456-216

Association between Dietary Inflammatory Index and Serum Tumor Necrosis Factor Alpha Level in Adult with Normal and Obese Body Mass Index in Jakarta

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Abstract:- Accumulating evidence identifies dietary intake may trigger chronic low-grade inflammation as potential mechanisms contributing to insulin resistance. However, studies regarding dietary inflammatory were inconsistent. An analysis of diet quality using dietary inflammatory index (DII) was conducted to investigate whether individual nutrition intake is proinflammation or anti-inflammation. The objective of this study was to understand the association between DII score and TNF-α in the normoweight and obese group. A cross-sectional study comprised 210 Indonesian adults in Jakarta. DII scores derived from two days of food recall were calculated based on 40 nutrients and food components, then serum TNF-α were measured using ELISA. Our data indicate a more proinflammatory diet, reflected by higher DII scores, was slightly higher in the obese group than the normoweight group (p=0,407). The overall DII score was not associated with serum TNF-α after adjustment for covariates (ß=0,001, p=0,895). However, when the DII score was classified into normoweight and obese group, the DII score in the normoweight group was significantly associated with serum TNF-α after adjustment for covariates (ß= 0,013, p=0,036), but not in the obese group. In conclusion, a positive association between DII score and serum TNF-α in the normoweight group level suggests that the diet's inflammatory properties regulate adipose tissue inflammation.

Keywords:- *Dietary quality, dietary inflammatory score, low-grade inflammation, obesity, TNF-α*

I. INTRODUCTION

The occurrence of overweight and obesity has become a problem in low- and middle-income countries despite the prevention programs and various efforts that have been done [1–3]. Indonesia, as one of Asia's middle-income countries, is also facing the same problem. As reported by the National Basic Health Survey in 2018, 21.8% of Indonesian adults were obese. Obesity is characterized by excess fat accumulation and chronic low-grade inflammation [4–6]. Crosstalk between adipocytes and macrophage triggered the release of proinflammatory cytokines [7,8]. The amount of TNF-α was higher among adipocytes when compared to IL-6 and other cytokines in adipocytes [9,10]. TNF-α plays a role in decreasing free fatty acid (FFA) uptake, synthesizing triglycerides and increasing lipolysis [11–13]. Increased levels of TNF-α could affect insulin signal regulation, induce insulin resistance, increasing the risk of non-communicable diseases [14–16].

It is known that inflammation is influenced by genes and environmental factors (e.g., lifestyle, diet, physical activity). Specifically, diets that could affect inflammatory markers in the circulation [17–19]. Diets consisting of high levels of refined sugar, flour, saturated fat, and trans-fat combined with an inadequate intake of rich fibers and antioxidant contents of fruits, vegetables, and whole grains might increase inflammation levels in the body [20–22]. The Dietary Inflammatory Index (DII) was developed to assess the inflammation of an individual diet and categorize it from maximal anti-inflammatory to maximal proinflammatory [23]. Previous studies have shown an association between DII score and annual weight gain, higher mean BMI, and inflammation markers [24,25]. However, there is still a lack of standardized value of average DII score. The objective of this study is to observe differences between DII score dan serum TNF-α in the normoweight and obese group among adults urban population of Jakarta.

II. MATERIAL AND METHODS

A. Study design

This research was a cross-sectional comparative study carried out among adult men and women between 18 to 55 years old living in the urban area of Jakarta, Indonesia. A total of 279 participants were recruited from a randomly-selected neighborhood in two sub district areas.

The inclusion criteria were men dan women aged 18-55 years, willing to participate in the study and signed informed consent. The exclusion criteria were men and women diagnosed with non-communicable diseases such as diabetes mellitus, chronic kidney disease, cancer, hypertension, and other chronic diseases, underweight/ overweight, took antibiotics, steroids, and fat-blocking drugs such as orlistat, underwent a weight loss program, and pregnant. Ethical approval was obtained from the Ethics Committee of the Faculty of Medicine, University of Indonesia (758/UN2.f1/etik/2017). Data and samples were obtained after participants signed the informed consent form. Obesity was determined by body mass index (BMI) and calculated by dividing body weight by height squared. Bodyweight was measured using a digital body mass scale (precision 0.01 kg, SECA, Germany). Height was measured using a portable stadiometer (0.01 cm precision, SECA, Germany). Waist circumference was measured using a non-elastic band (0.1 cm precision, SECA, Germany). All anthropometric measurements were conducted by trained personnel using calibrated instruments. Food intake data were collected using 2-day, 24-hour food recall on weekdays and weekends. Validated food photos, household measures (bowls and plates) and calibrated household utensils were provided for portion size estimation.

B. Data analysis

The analysis mainly used the Indonesian food composition database, and some nutrient values were borrowed from Thailand, Malaysia, Singapore, and the USDA food composition database. Data collection for dietary intake were done by a face-to-face interview between trained nutritionists and participants.

The DII score was calculated according to Shivappa et al. [23]. The adjusted DII was calculated from 40 nutrients and dietary components, including total energy, protein, carbohydrates, total fat, saturated fat, trans fat, monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), omega-3 fatty acids, omega-6 fatty acids, cholesterol, fiber, magnesium, iron, selenium, zinc, vitamin A, vitamin C, vitamin D, vitamin E, thiamin, riboflavin, vitamin B6, vitamin B12, folate, niacin, beta- carotene, alcohol, caffeine, tea, onions, ginger, garlic, pepper, turmeric, and flavonoids. Data for other dietary factors by Shivappa were not available, such as rosemary, oregano, and saffron. Individual DII scores were obtained by subtracting the global mean intake to the individual reported food intake data of each nutrient and then dividing the standard deviation of global daily intake, resulting in a z-score. Then, z-scores were converted into percentile rank and centralized percentile score. The percentile scores were multiplied by the overall inflammatory effect score to form nutrient-specific effect scores. Finally, all nutrient-specific effects were summed to obtain a DII score.

Data on physical activity were collected using the International Physical Activity Questionnaire (IPAQ) short form. This questionnaire contained information on the intensity and duration of several activities, including physical activity patterns in and around the house, travel to work, activities at work, and recreation. All activity reported in IPAQ was converted to MET minutes/week. IPAQ short form was developed, validated, and used previously [26,27].

From each participant, a 5-mL blood sample was collected into a plain tube. The serum was isolated and stored at -800C until further analysis. Serum TNF-α levels were measured using the enzyme-linked immunosorbent assay (ELISA). The assay sensitivity range of the R&D Human TNF-α Quantikine ELISA kit was 0.5 - 32 pg/mL.

Statistical analysis was performed using SPSS version 16.0. The Kolmogorov-Smirnov goodness-of-fit test was used to check the normality of each variable. Descriptive characteristics were expressed as mean ± SD for normally distributed data and median (IQR) for non-normal data. The comparison of baseline characteristics with obesity status and TNF-α were made by independent sample t-test for continuous variables, and associations were assessed using the Chi-square test for categorical variables. A p-value less than 0.05 was considered statistically significant. The relationship between the DII score as the independent variable and BMI as the dependent variable was analyzed using logistic regression. The relationship between the DII score as the independent variable and the TNF-α serum concentration as the dependent variable was analyzed using linear logistic regression. Adjustments for age, sex, marital status, education, occupation, physical activity and energy intake, waist circumference, and BMI, where relevant, were also conducted.

III. RESULTS

A. DII Scores in Normoweight and Obese Groups

In this study, 76 participants with norm weight and 134 obese were investigated. Table 1 showed the baseline characteristics of norm weight and obese participants, and Table 2 showed the anthropometric measurement of participants. Significant differences between norm weight and obese groups were found in gender, age group, marital status, length of formal education expenditure, smoking status, and waist circumference size.

The amount of pro inflammatory nutrition intake is shown in Table 3. Compared to the normo weight group, participants in the obese group had a relatively low intake of proinflammatory components such as total energy, carbohydrate, protein, and vitamin B12. They had relatively high anti-inflammatory (Table 4) components such as fiber, MUFA, FA n-3, FA n-6, vitamin A, thiamine, niacin, vitamin B6, folic acid, ß-carotene, magnesium, Flava-3ol, flavones, flavanols, anthocyanidin, and pepper, although the differences were not significant.

The DII score in this study was shown in Table 5. with a mean value of -0.038 ± 2.07. It showed that DII mean score in the obese group was higher compared to the normo weight. The difference between the two groups was not significant ($p = 0.407$). Multivariate analysis in Table 6 showed no significant differences observed even after adjusting for physical activities and expenses, formal education, energy intake, age group, smoking, marital status, and waist circumference. The more precise Model IX showed that the DII score increased the incidence of obesity when analyzed by

ISSN No:-2456-216

sex (OR = 1.23, CI = 0.69-2.19), although the difference was not significant.

B. DII Score and TNF- α

The TNF-α serum examination was carried out after 72 samples were taken randomly for data analysis. The general characteristics of participants in the research sub-sample based on serum TNF-α levels can be seen in Table 7. There was a significant gender difference. Table 8 showed a significant

Variable	Normoweight (n=76) n (%)	Obese (n=134) n (%)	OR (CI95%)	p-value
Gender				**0.023** [CS]
Men	37 (48.7)	44 (32.8)	1	
Women	39 (51.3)	90 (67.2)	1.94 (1.09-3.54)	
Age group				**<0.001** [CS]
Younger adult	64 (84.2)	66 (49.3)	1	
Middle adult	12 (15.8)	68 (50.7)	5.49 (2.72-11.10)	
Marital status				**<0.001** [CS]
Not married/divorced	58 (76.3)	46 (34.3)	1	
Married	18 (23.7)	88 (65.7)	6.16 (3.26-11.66)	
Formal education				**0.012** [CS]
≤ 9 years	71 (93.4)	108 (80.6)	1	
>9 years	5 (6.6)	26 (19.4)	3.42 (1.25-.80)	
Occupation				0.262 [CS]
Not working	3 (3.9)	2 (1.5)	1	
Working	73 (96.1)	132 (98.5)	2.71 (0.44-16.60)	
Expense				**0.006** [CS]
Tertile 1	19 (25)	34 (25.4)	3.06 (1.53-6.11)	
Tertile 2	29 (38.2)	76 (56.7)	2.09 (0.95-4.57)	
Tertile 3	28 (36.8)	24 (17.9)	1	
Smoking status				**0.025** [CS]
Yes	15 (19.7)	12 (9)	1	
No	61 (81.3)	122 (91)	2.50 (1.10-5.67)	
Physical Activtites[2]				0.810 [CS]
Low	24 (32.6)	37 (27.6)	1	
Middle	29 (38.2)	56 (41.8)	1.25 (0.63-2.48)	
High	23 (30.3)	41 (30.6)	1.16 (0.56-2.39)	

Table 1 : General Characteristic of Participant in Normoweight and Obese Groups (n=210)

[1]Expense: Tertile 1=IDR 1,872,166.00 - IDR 3,363,749.00; Tertile 2 IDR 3,363,750.00 – IDR 9,227,499.00; Tertile 3: IDR 9,227,500.00 – IDR 16,344,000.00

[2]Physical activities: Low= if not middle or high; Middle= PAL ≥ 600 MET/Week; High = PAL ≥3000 MET/week
[CS]chi-square test

Variable	Mean ± SD/ Median (25^{th},75^{th})		p-*value*
	Normoweight **(n=76)**	**Obese (n=134)**	
Waist circumference (cm)	74.3 ± 6.5	92.9 ± 10.7	<0.001 [T]
BMI (kg/m2)	21.2 (20; 22.5)	29.6 (27; 32.7)	<0.001 [MW]

Table 2 : Body Composition in *Normoweight* and Obese Groups (n=210)

BMI= Body Mass Index
[MW] Mann-Whitney test
[T] Independent T-test

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Nutrient	Mean ± SD /Median (25^{th},75^{th})		p-*value*
	Normoweight **(n=76)**	**Obese (n=134)**	
Energy intake (kcal)	1582 (1258 - 1860)	1460 (1153 - 2012)	0.579 MW
Carbohydrate (g)	217 (169 - 259)	187 (149 - 251)	0.131 MW
Protein (g)	54.2 (43.2 - 66.8)	52.3 (35.9 - 69.8)	0.474 MW
Total Fat (g)	51.7 (44.7 - 75.5)	54 (39.1 - 79.2)	0.611 MW
SAFA (g)	23.9 (16.0 - 33.2)	26.3 (16.2 - 38.3)	0.151 MW
Lemak-*trans* (g)	0.08 (0.03 - 0.30)	0.08 (0.03 - 0.25)	0.824 MW
Cholesterol (mg)	169 (115 - 286)	204 (96 - 292)	0.829 MW
Vitamin B12 (µg)	2.1 (1.2 - 5.2)	2.0 (1.1 - 4.7)	0.410 MW
Iron (mg)	7.4 (5.8 - 11.4)	8.0 (5.6 - 15.1)	0.256 MW

Table 3 : Comparison of Proinflammation Nutrient in *Normoweight* and Obese Groups (n=210)

MW Mann-Whitney test

Nutrient	Mean ± SD /Median (25^{th},75^{th})		p-*value*
	Normoweight **(n=76)**	**Obese (n=134)**	
Fiber (g)	8.8 (5.9 - 12.5)	9.5 (6.5 - 13.8)	0.270 MW
PUFA (g)	14.0 (8.5 - 20.9)	14.1 (9.2 - 20.4)	0.586 MW
MUFA (g)	11.4 (8.4 - 16.3)	12.5 (8.8 - 17.4)	0.512 MW
FA *n*-3 (g)	0.47 (0.24 - 0.94)	0.51 (0.22 - 1.36)	0.643 MW
FA *n*-6 (g)	4.6 (2.4 -10.6)	5.67 (3.2-10.9)	0.292 MW
Vitamin A (RE)	1189 (712.7 - 1923.9)	1372 (925-1956)	0.480 MW
Vitamin C (mg)	28.3 (13.7 - 57.4)	27.3 (13.7 - 57.4)	0.623 MW
Vitamin D (µg)	2.13 (0.66 - 65.95)	1.32 (0.59 - 3.16)	0.113 MW
Vitamin E (mg)	3.0 (2.5 - 4.1)	3.6 (2.5 - 5.4)	0.087 MW
Thiamin (mg)	0.55 (0.40 - 1.18)	0.60 (0.44 - 1.20)	0.150 MW
Niacin (mg)	8.2 (6.6 - 11.2)	9.8 (6.4 - 15.9)	0.340 MW
Riboflavin (mg)	0.70 (0.50 - 1.15)	0.50 (0.50 - 1.05)	0.839 MW
Vitamin B6 (mg)	0.95 (0.75 - 1.69)	1.05 (0.70 - 1.58)	0.940 MW
Folate acid (µg)	91.8 (57.0 - 131.6)	98.7 (69.9 - 131.7)	0.308 MW
ß-carotene (µg)	1152 (471 - 2524)	1398(609 - 2727)	0.193 MW
Mg (mg)	133 (110 - 176)	143 (109 -202.)	0.509 MW
Se (µg)	50.6 (33.6 - 79.3)	48.4 (32.7 - 71.0)	0.601 MW
Zn (mg)	5.4 (3.9 - 6.8)	5.3 (3.8 - 6.8)	0.834 MW
Flavan-3-ol (mg)	6.3 (1.1 - 50.2)	7.6 (1.2 - 47.3)	0.925 MW
Flavones (mg)	2.8 (1.2 - 7.0)	3.0 (1.4 - 6.5)	0.438 MW
Flavanols (mg)	0.00 (0.00 - 0.31)	0.07 (0.00 - 0.57)	0.132 MW
Flavanones (mg)	11.1 (5.6 - 17.7)	10.3 (5.7 - 17.1)	0.681 MW
Anthocyanidin (mg)	1.25 (0.55 - 3.85)	1.33 (0.55 - 3.34)	0.968 MW
Isoflavone (mg)	10.13 (0.09 - 30.17)	9.21(0.12 - 25.47)	0.897 MW
Caffein (g)	0.01 (0.00 - 0.04)	0.02 (0.00 - 0.06)	0.161 MW
Garlic (g)	3.7 (1.4 - 8.4)	3.2 (1.8 - 7.9)	0.972 MW
Ginger (g)	0.00 (0.00 - 0.70)	0.00 (0.00 - 0.53)	0.866 MW
Onion (g)	6.7 (2.3 - 16.5)	6.2 (3.3 - 12.8)	0.889 MW
Turmeric (mg)	0.00 (0.00 - 0.07)	0.00 (0.00 - 0.07)	0.891 MW
Tea (g)	1.00 (0.00 - 3.15)	1.00 (0.00 - 2.58)	0.890 MW
Pepper (g)	0.23(0.02 - 0.88)	0.27 (0.05 - 0.77)	0.911 MW

Table 4 : Comparison of Anti-Inflammation Nutrient in *Normoweight* and Obese Groups (n=210)

MW Mann-Whitney test

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DII scores	Mean	St. deviation	Minimum	Maximum	p-*value*
Normoweight (n=76)	-0.20	2.20	-7.55	6.12	0.407 [T]
Obese (n=134)	0.05	1.99	-5.30	5.30	
Total (n=210)	-0.04	2.07	-7.55	6.12	

Table 5. Descriptive Data of DII Score in *Normoweight* and Obese Groups (n=210)

[T] Independent T test

relationship in waist circumference with TNF-α serum levels with r values of 0.262 and p-0.026. Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.

The DII score in the subsample had a mean value of 0.39 ± 2.14. The minimum score of DII was -4.31, and the maximum value was 6.12. The serum TNF-α value in this study was 7.01 pg/ml with a minimum value of 4.87 pg/ml and a maximum value of 12.20 pg/ml. Because the TNF-α data were not normally distributed when the Kolmogorov-Smirnov test was carried out, the TNF-α data normalization

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Variable	Model I OR (CI95%)	Model II OR (CI95%)	Model III OR (CI95%)	Model IV OR (CI95%)	Model V OR (CI95%)	Model VI OR (CI95%)	Model VII OR (CI95%)	Model VIII OR (CI95%)	Model IX OR (CI95%)
DII scores									
Low	1	1	1	1	1	1	1	1	1
High	0.40 (0.08-1.92)	0.55 (0.13-2.40)	0.60 (0.14-2.49)	0.63 (0.15-2.58)	0.73 (0.21-2.59)	0.78 (0.23-2.71)	0.92 (0.28-3.00)	0.96 (0.30-3.06)	1.23 (0.69-2.19)
Gender									
Men	1	1	1	1	1	1	1	1	1
Women	32.95 (4.25-225.61)*	20.48 (3.48-120.68)*	20.03 (3.51-114.19)*	19.70 (3.48-111.69)*	17.46 (3.32-91.68)*	14.96 (3.16-70.74)*	17.91 (3.96-80.90)*	23.12 (5.19-102.87)*	1.98 (1.11-3.54)*
Age group									
Young adult	1	1	1	1	1				
Middle adult	0.48 (0.07-3.32)	0.46 (0.06-3.23)	0.58 (0.10-3.45)	0.61 (0.10-3.57)	0.60 (0.10-3.53)				
Marital status									
Not Married	1	1	1	1	1	1	1		
Married	4.40 (0.84-23.15)	3.48 (0.66-18.19)	3.39 (0.63-17.05)	3.42 (0.67-17.46)	2.99 (0.65-13.82)	2.29 (0.67-7.82)	2.14 (0.64-7.19)		
Formal education									
> 9 years	1	1	1						
≤ 9 years	1.38 (0.11-16.66)	1.95 (0.16-23.06)	1.75 (0.15-20.83)	-	-	-	-	-	-
Expense									
Tertile 3	1	1							
Tertile 2	1.32 (0.27-6.33)	1.64 (0.37-7.24)	-	-	-	-	-	-	-
Tertile 1	0.60 (0.08-4.60)	0.85 (0.12-5.94)							
Smoking									
Yes	1	1	1	1	1	1	-	-	-
No	2.58 (0.24-28.14)	2.09 (0.23-19.19)	2.54 (0.30-21.55)	2.37 (0.29-19.46)	2.14 (0.28-16.59)	2.50 (0.35-17.90)			
Physical Activities									
Low	1	-	-	-	-	-	-	-	-
Middle	4.15(0.76-22.80)								
High	0.85 (0.18-4.01)								
Waist circumference	1.63 (1.35-1.97)*	1.56 (1.32-1.85)*	1.56 (1.32-1.83)*	1.56 (1.32-1.83)*	1.56 (1.32-1.83)*	1.53 (1.32-1.78)*	1.53 (1.32-1.77)*	55 (1.34-1.79)	-
Energy intake	1.00 (0.99-1.00)	1.00 (0.99-1.00)	1.00 (0.99-1.00)	1.00 (0.99-1.00)	-	-	-	-	-

Table 6 : DII Scores in *Normoweight* and Obese Group (n=210)

OR=Odds Ratio, CI=Confidence Interval,*variable with p<0.05

Model 1 Full Model
Model 2 without physical activities
Model 3 without physical activities and expenses
Model 4 without physical activities and expenses, and formal education
Model 5 without physical activities and expenses, formal education, and energy intake
Model 6 without physical activities and expenses, formal education energy intake, and age group
Model 7 without physical activities and expenses, formal education energy intake, age group, and smoking
Model 8 without physical activities and expenses, formal education energy intake, age group,smoking, and marital status
Model 9 without physical activities and expenses, formal education energy intake, age group, smoking, marital status, waist circumferences

were carried out for multivariate analysis and then presented in the form of geometric means (0.85 ± 0.09). Pearson correlation test showed no significant relationship between DII and TNF-α (r = -0.002).

Multiple regression analysis was performed to assess the association between DII and TNF-α serum levels by controlling for factor covariates. Table 9 showed the analysis in three models. There was no relationship between DII and TNF-α serum levels after controlling for covariate factors with p = 0.895. In the last model, the covariate factors that can affect the relationship between DII score and TNF-α serum levels are gender (ß = -0.076, CI = -0.113 - -0.029), and BMI (ß = 0.003, CI = -0.001 - 0.005).

Subsequently, multiple regression analysis was performed for each normoweight and obese group. Table 10 showed the sub-analysis in the normoweight group. There is a correlation between scores DII and serum TNF-α levels after the covariate factors were controlled, as found in model III with p-value = 0.036. The expense was a confounding variable that could affect the relationship between DII scores and serum TNF-α levels in the normoweight group (ß = -0.043, CI = -0.078 - -0.009). An increased DII score of 1 would increase serum levels of TNF-α by 0.013 pg/ml in the normoweight group.

Multiple regressions in the obese group in Table 11 showed no significant relationship between the DII score and the TNF-α serum level (p = 0.692). Several confounding variables that could affect the relationship between DII score and TNF-α serum level in the obese group were gender (ß = -0.134, CI = -0.185 - -0.084) and BMI (ß = -0.005, CI = -0.001 - 0.010).

Variable	**n**	**TNF-α**	
		Mean±SD/ Median(25^{th};75^{th})	**p-*value***
Gender			**<0.001** [T]
Men	33	0.90 ± 0.82	
Women	39	0.82 ± 0.07	
Age group			0.929 [T]
Younger adult	55	0.86 ± 0.09	
Middle adult	17	0.86 ± 0.09	
Marital status			**0.177**[MW]
Married	32	0.88 (0.80; 0.91)	
Not married/divorced	40	0.82 (0.78; 0.90)	
Formal education			**0.135**[MW]
>9 years	10	0.80 (0.75; 0.86)	
≤ 9 years	62	0.85 (0.80; 0.91)	
Occupation			0.729[MW]
Not working	3	0.89 (0.80; 0.89)	
Working	69	0.84 (0.79; 0.91)	
Expenses			**0.189**[A]
Tertile 1	15	0.86 ± 0.08	
Tertile 2	34	0.87 ± 0.09	
Tertile 3	23	0.83 ± 0.08	
Smoking status			0.606[T]
No	62	0.86 ± 0.09	
Yes	10	0.87 ± 0.09	
Physical Activtites[2]			0.470[KW]
Low	22	0.82 (0.78; 0.91)	
Middle	26	0.89 (0.81; 0.92)	
High	24	0.84 (0.78; 0.90)	

Table 7 : General Characteristics of Research Participants Based on TNF-α[1] (n=72)

[1]Log transform and presented with geometric means
[A]ANOVA
[T] Independent T-test
[KW]Kruska-wallis

Variable	**Serum TNF-α**	
	r	**p-*value***
BMI	0.152	0.152[S]
Waist Circumferences	0.262	**0.026[P]**
Energy Intake	0.165	0.165[P]

Table 8 : Correlation of Participant Body Composition and Energy Intake Based on TNF-α (n-72)

[S]Spearman Correlation
[P]Pearson Correlation

Variable	Model 1			Model 2			Model 3		
	ß	95%	p-value	ß	95%	p-value	ß	95%	p-value
DII scores	0.003	-0.007 - 0.013	0.538	0.002	-0.007 – 0.011	0.680	0.001	-0.008 – 0.009	0.844
Gender	-0.720	-0.118 - -0.026	0.003	-0.071	-0.113 – -0.030	0.001	-0.076	-0.113 – -0.039	0.001
Marital status	-0.020	-0.065 - 0.025	0.386	-	-	-	-	-	-
Formal education	0.043	-0.030 - 0.025	0.224	0.054	-0.012 – 0.119	0.105	-	-	-
Expenses	-0.025	-0.055 - 0.005	0.096	-0.024	-0.053 - 0.005	0.097	-	-	-
BMI	0.002	-0.007- 0.011	0.628	0.003	-0.001 – 0.006	0.151	0.002	-0.001 – 0.005	0.225
Waist circumferences	0.000	-0.003 - 0.004	0.875	-	-	-	-	-	-
Energy intake	- 0.000024	0.000 - 0.000	0.335	-0.000017	0.000 – 0.000	0.456	-	-	-
Physical activities	-0.007	-0.031 - 0.017	0.558	-	-	-	-	-	-

Table 9 : Multiple Regression DII Score with TNF-α[1,2] (n=72)

[1]Log transform and presented with geometric means
[2] Enter method
Model 1: adjustment for gender, marital status, formal education, expense, BMI, waist circumference, energy intake, and physical activities
Model 2: adjustment for gender, formal education, expense, BMI, energy intake
Model 3: adjustment for gender and BMI

Variable	**Model 1**			**Model 2**			**Model 3**		
	ß	**95%**	**p-value**	**ß**	**95%**	**p-value**	**ß**	**95%**	**p-value**
DII scores	0.011	-0.004 - 0.026	**0.156**	0.012	-0.002 – 0.026	**0.080**	0.013	0.001 – 0.025	**0.036**
Gender	-0.019	-0.085 - 0.048	0.571	-	-	-	-	-	-
Marital status	-0.003	-0.077 - 0.070	0.929	-	-	-	-	-	-
Formal education	0.089	-0.106 - 0.285	0.356	-	-	-	-	-	-
Expenses	-0.048	-0.091 - -0.005	**0.030**	-0.045	-0.082 - -0.009	**0.016**	-0.043	-0.078 - - 0.009	**0.009**
BMI	0.015	-0.013 - 0.044	**0.277**	0.006	-0.015 – 0.027	0.569	-	-	-
Waist circumferences	-0.002	-0.008 - 0.003	0.345	-	-	-	-	-	-
Energy intake	0.000003	0.000 - 0.000	0.953	-0.000007	0.000 – 0.000	0.847	-	-	-
Physical activities	0.006	-0.032 - 0.044	0.745	-	-	-	-	-	-

Table 10 : Multiple Regression DII score with TNF-α[1] in Normoweight[2] Group(n=34)

[1]Log transform and presented with geometric means
[2] Enter method
Model 1: adjustment for gender, marital status, formal education, expense, BMI, waist circumference, energy intake, and physical activities
Model 2: adjustment for expenses, BMI, and energy intake
Model 3: adjustment for expenses

ISSN No:-2456-216

Variabel	Model 1			Model 2		
	ß	95%	p-value	ß	95%	p-value
DII scores	-0.003	-0.017 - 0.011	0.631	-0.007	-0.017 - 0.004	0.211
Gender	-0.121	-0.202 - -0.039	**0.005**	-0.114	-0.159 - -0.069	**<0.001**
Marital status	0.016	-0.045 - 0.076	0.602	-	-	-
Formal education	-0.006	-0.085 - 0.072	0.875	-	-	-
Expenses	-0.005	-0.049 - 0.040	0.835	-	-	-
BMI	-0.001	-0.013 - 0.012	0.924	0.003	-0.002 - 0.008	0.175
Waist circumferences	0.003	-0.004 - 0.009	0.403	-	-	-
Energy intake	-0.000038	0.000 - 0.000	0.214	-	-	-
Physical activities	-0.003	-0.036 - 0.029	0.848	-	-	-

Table 11 : Multiple Regression DII Score with TNF-α[1] in Obese[2] Group(n=38)

[1]Log transform and presented with geometric means
[2] Enter method

Model 1: adjustment for gender, marital status, formal education, expense, BMI, waist circumference, energy intake, and physical activities
Model 2: adjustment for gender and BMI

IV. DISCUSSION

This study was aimed to evaluate the relationship between DII scores with BMI dan TNF-α in the urban adult population of Jakarta, Indonesia. We found that the DII score was not correlated with BMI and TNF-α. Interestingly, we showed that the DII score was positively correlated with TNF-α after correcting gender among the normoweight group.

We compared the intake of the components of the DII between the normoweight group and the obese group. Compared to the normoweight group, participants in the obese group had a lower intake of proinflammatory components such as total energy, carbohydrate, protein vitamin B12, and higher anti-inflammatory component such as fiber, MUFA, FA n-3, FA n-6, vitamin A, thiamine, niacin, vitamin B6, folic acid, ß-carotene, magnesium, Flava-3ol, flavones, flavanols, anthocyanidin, and pepper. The mean energy intake of the participants in this study is lower than the Indonesian dietary recommendation [RISKESDAS]. The short-duration dietary data captured in this study might not reflect the actual dietary patterns of the participants. Another possible explanation is that the majority of the obese group participants are willing to participate and have relatively better awareness than the general public [28]. These factors can influence obesity in this study to regulate food intake compared to normal body weight.

This study began with findings from previous studies that explained the role of DII in the development of obesity [24]. However, there was no difference in the DII score between the normoweight and the obese group in this study. This finding is similar to the cross-sectional study done previously [29]. Based on the previous studies and our findings, the effect of DII on nutritional status represented by BMI remains inconclusive. Well-controlled long-term intervention studies are needed to shed more light on the role of DII in obesity.

There is more convincing evidence that inflammation is an important link between obesity and insulin resistance [30–32]. Insulin resistance is associated with overexpression of TNF-α in adipose tissue [33,34]. This study showed that the DII score was not correlated with serum TNF-α. Furthermore, the sub-analysis of each group showed a correlation between DII scores and TNF-α in the normoweight group after adjusting for expenses but not in the obese group. Comparable to this study, a cross-sectional study conducted among police officers showed no correlation between DII scores with TNF-α levels [35]. In contrast, a case-control study to examine the relationship between DII and the risk of gastric cancer showed that the DII score had an acceptable correlation with TNF-α [36]. A similar association was also found in several cross-sectional studies to assess the risk of metabolic syndrome, in which higher DII scores showed a higher concentration of TNF-α [37,38]. These studies' discrepancies might be caused by a significant correlation between waist circumference with TNF-α, which overshadowed the correlation between DII scores with TNF-α. Waist circumference that illustrated the amount of visceral fat tissue is known to be positively correlated with TNF-α.

Another possible explanation of the absence of the relationship between the DII score and the TNF-α level is the component of the DII score which does not have a strong relationship with TNF-α. Of the total 40 nutrients in this study, the intake that had a significant correlation with the TNF-α serum level was total fat, SAFA, MUFA, n-6 fatty acids, vitamin C, vitamin E. Fat intake showed to have an effect on the serum TNF-α levels. A study by Lennie et al. [39] showed that serum TNF-α levels were elevated in patients with high SAFA intake. A study by Gonzales et al. [40] comparing MUFA intake in middle age compared with the elderly showed that high MUFA and PUFA intakes were significantly associated with increased TNF-α levels. Vitamin C can significantly reduce ROS levels, DNA damage, and TNF-α [41]. The literature showed that vitamin E supplementation ≥700 mg/day for more than eight months could reduce TNF-α levels. However, a positive correlation between vitamin E and serum TNF-α was observed [42]. This difference might occur because, in the present study, the vitamin E data obtained from the 24-hour food recall illustrates a momentary intake that could not be directly related to serum TNF-α levels [43].

Meanwhile, the included participants were without non-communicable diseases such as diabetes mellitus, chronic kidney disease, cancer, hypertension, or taking drugs such as antibiotics, steroids, and fat-blocking drugs because we wanted to investigate the role of diet in the early development of chronic diseases. Thus, our study population is relatively healthier than the general urban adult population of Jakarta, which might also lead to the lack of association between DII scores and TNF-α.

Further research using a prospective study design to find a causal relationship between diet, obesity, and serum TNF-α levels is recommended. We also suggest the Development of a specific SQ-FFQ related to DII that suits the Indonesian population to get more accurate information regarding nutritional intake that can affect inflammation in the body.

V. CONFLICT OF INTEREST

The authors declare there is no conflict of interest.

VI. ACKNOWLEDGMENT

This study was a part of the DIOCROME project conducted at the Human Nutrition Research Center, IMERI, Faculty of Medicine, University of Indonesia. The author would like to thank all participants and enumerators who participated in the data collection.

REFERENCES

[1] G Dyer S, Diong J, Crotty M, Sherrington C. Rehabilitation Following Hip Fracture. In: Falaschi P, Marsh DR, editors. Orthogeriatrics [Internet]. Cham: Springer International Publishing; 2017. p. 145–63. Available from: http://dx.doi.org/10.1007/978-3-319-43249-6_10

[2] Hruby A, Hu FB. The Epidemiology of Obesity: A Big Picture. PharmacoEconomics. 2015 Jul;33(7):673–89.

[3] Bhurosy T, Jeewon R. Overweight and obesity epidemic in developing countries: a problem with diet, physical activity, or socioeconomic status? ScientificWorldJournal. 2014/10/14 ed. 2014;2014:964236–964236.

[4] Tim Riskesdas 2018. Laporan Nasional RISKEDAS 2018. Badan Penelitian dan Pengembangan Kesehatan; 2019.

[5] Andrei AM, Berbecaru-Iovan A, Din-Anghel FRI, Stănciulescu CE, Berbecaru-Iovan S, Baniţă IM, et al. Interplay between Hypoxia, Inflammation and Adipocyte Remodeling in the Metabolic Syndrome. 2017 [cited 2017 Aug 6]; Available from: http://www.intechopen.com/books/hypoxia-and-human-diseases/interplay-between-hypoxia-inflammation-and-adipocyte-remodeling-in-the-metabolic-syndrome

[6] Hotamisligil GS, Erbay E. Nutrient sensing and inflammation in metabolic diseases. Nat Rev Immunol. 2008 Dec;8(12):923.

[7] Borst SE. The role of TNF-α in insulin resistance. Endocrine. 2004 Mar 1;23(2):177–82.

[8] Dandona P, Ghanim H, Chaudhuri A, Dhindsa S, Kim SS. Macronutrient intake induces oxidative and inflammatory stress: potential relevance to atherosclerosis and insulin resistance. Exp Mol Med. 2010 Apr 30;42(4):245–53.

[9] Giugliano D, Ceriello A, Esposito K. The Effects of Diet on Inflammation. J Am Coll Cardiol. 2006 Aug 15;48(4):677–85.

[10] Bianchi VE. Weight loss is a critical factor to reduce inflammation. Clin Nutr ESPEN. 2018 Dec;28:21–35.

[11] Ahluwalia N, Andreeva VA, Kesse-Guyot E, Hercberg S. Dietary patterns, inflammation and the metabolic syndrome. Diabetes Metab. 2013 Apr 1;39(2):99–110.

[12] Shivappa N, Steck SE, Hurley TG, Hussey JR, Hébert JR. Designing and developing a literature-derived, population-based dietary inflammatory index. Public Health Nutr. 2014 Aug;17(8):1689–96.

[13] Wirth M, Burch J, Shivappa N, Violanti JM, Burchfiel CM, Fekedulegn D, et al. Association of a Dietary Inflammatory Index with Inflammatory Indices and the Metabolic Syndrome among Police Officers. J Occup Environ Med Am Coll Occup Environ Med. 2014 Sep;56(9):986–9.

[14] Ramallal R, Toledo E, Martínez JA, Shivappa N, Hébert JR, Martínez-González MA, et al. Inflammatory potential of diet, weight gain, and incidence of overweight/obesity: The SUN cohort. Obes Silver Spring Md. 2017 Jun;25(6):997–1005.

[15] Ruiz-Canela M, Zazpe I, Shivappa N, Hébert JR, Sánchez-Tainta A, Corella D, et al. Dietary inflammatory index and anthropometric measures of obesity in a population sample at high cardiovascular risk from the PREDIMED (PREvención con DIeta MEDiterránea) trial. Br J Nutr. 2015 Mar;113(6):984–95.

[16] Lee PH, Macfarlane DJ, Lam T, Stewart SM. Validity of the international physical activity questionnaire short form (IPAQ-SF): A systematic review. Int J Behav Nutr Phys Act. 2011 Oct 21;8(1):115.

[17] Pengpid S, Peltzer K. Hand grip strength and its sociodemographic and health correlates among older adult men and women (50 years and older) in indonesia. Curr Gerontol Geriatr Res. 2018 Dec 3;2018:1–8.

[18] Purnama H, Suhada T. Tingkat aktivitas fisik pada lansia di provinsi jawa barat, indonesia. J Keperawatan Komprehensif. 2019 Aug 20;5(2):102.

[19] Suyoto PST, Huriyati E, Susilowati R, Julia M. Relative Validity of Administered Indonesian Version of the Short-Form International Physical Activity Questionnaire (IPAQ-SF) among Obese Adolescent Girl Population. Pak J Nutr. 2016 Sep 1;15(9):816–20.

[20] Kementrian Kesehatan Republik Indonesia. Angka Kecukupan Gizi Yang Dianjurkan Untuk Masyarakat Indonesia [Internet]. Sect. Lampiran 1, PERATURAN MENTERI KESEHATAN REPUBLIK INDONESIA NOMOR 28 TAHUN 2019 Agustus, 2019 p. 6–14. Available from: http://hukor.kemkes.go.id/uploads/produk_hukum/PMK_No__28_Th_2019_ttg_Angka_Kecukupan_Gizi_Yang_Dianjurkan_Untuk_Masyarakat_Indonesia.pdf

[21] Tucker KL. Assessment of usual dietary intake in population studies of gene–diet interaction. Nutr Metab Cardiovasc Dis. 2007 Feb;17(2):74–81.

[22] Muhammad HFL, van Baak MA, Mariman EC, Sulistyoningrum DC, Huriyati E, Lee YY, et al. Dietary Inflammatory Index Score and Its Association with Body Weight, Blood Pressure, Lipid Profile, and Leptin in Indonesian Adults. Nutrients. 2019 Jan 11;11(1):148.

[23] Moe San KM, Fahmida U, Wijaksono F, Lin H, Zaw KK, Htet MK. Chronic low grade inflammation measured by dietary inflammatory index and its association with obesity among school teachers in Yangon, Myanmar. Asia Pac J Clin Nutr. 26(6).

[24] Kord Varkaneh Hamed, Fatahi Somaye, Tajik Somaye, Rahmani Jamal, Zarezadeh Meysam, Shab-Bidar Sakineh. Dietary inflammatory index in relation to obesity and body mass index: a meta-analysis. Nutr Food Sci. 2018 Jan 1;48(5):702–21.

[25] Shoelson SE. Inflammation and insulin resistance. J Clin Invest. 2006 Jul 3;116(7):1793–801.

[26] Olefsky JM, Glass CK. Macrophages, inflammation, and insulin resistance. Annu Rev Physiol. 2010 Mar 17;72(1):219–46.

[27] Nieto-Vazquez I, Fernández-Veledo S, Krämer DK, Vila-Bedmar R, Garcia-Guerra L, Lorenzo M. Insulin resistance associated to obesity: the link TNF-alpha. Arch Physiol Biochem. 2008 Jul;114(3):183–94.

[28] Tzanavari T, Giannogonas P, Karalis KP. TNF-α and Obesity. 2010;11:145–56.

[29] Vahid F, Shivappa N, Faghfoori Z, Khodabakhshi A, Zayeri F, Hebert JR, et al. Validation of a Dietary Inflammatory Index (DII) and Association with Risk of Gastric Cancer: a Case-Control Study. Asian Pac J Cancer Prev APJCP. 2018 Jun 25;19(6):1471–7.

[30] Phillips CM, Shivappa N, Hébert JR, Perry IJ. Dietary Inflammatory Index and Biomarkers of Lipoprotein Metabolism, Inflammation and Glucose Homeostasis in Adults. Nutrients. 2018 Aug 8;10(8):1033.

[31] Shivappa N, Hebert JR, Marcos A, Diaz L-E, Gomez S, Nova E, et al. Association between dietary inflammatory index and inflammatory markers in the HELENA study. Mol Nutr Food Res. 2017 Jun;61(6).

[32] Wehling H, Lusher J. People with a body mass index ⩾30 under-report their dietary intake: A systematic review. J Health Psychol. 2017 Jul 21;24(14):2042–59.

[33] Lennie TA, Chung ML, Habash DL, Moser DK. Dietary fat intake and proinflammatory cytokine levels in patients with heart failure. J Card Fail. 2005 Oct;11(8):613–8.

[34] Gonzalez-Quintela A, Campos J, Loidi L, Quinteiro C, Perez L-F, Gude F. Serum TNF-alpha levels in relation to alcohol consumption and common TNF gene polymorphisms. Alcohol Fayettev N. 2008 Sep;42(6):513–8.

[35] Chen Y, Luo G, Yuan J, Wang Y, Yang X, Wang X, et al. Vitamin c mitigates oxidative stress and tumor necrosis factor-alpha in severe community-acquired pneumonia and lps-induced macrophages. Mediators Inflamm. 2014;2014:1–11.

[36] Asbaghi O, Sadeghian M, Nazarian B, Sarreshtedari M, Mozaffari-Khosravi H, Maleki V, et al. The effect of vitamin E supplementation on selected inflammatory biomarkers in adults: a systematic review and meta-analysis of randomized clinical trials. Sci Rep. 2020 Oct 14;10(1):17234.