April – June, 2024
Original Article
DOI: http://dx.doi.org/10.30867/action.v9i2.1364

AcTion: Aceh Nutrition Journal
Pages: 194 – 202
p-issn 2527-3310; e-issn 2548-5741

The comparison of Dietary Inflammatory Index (DII) value in obesity and non-obesity

Perbandingan nilai Dietary Inflammatory Index (DII) pada obesitas dan non-obesitas

Fani Khairunnisa Rakhman[1], Lirista Dyah Ayu Oktafiani[2*]

[1] Program Studi Gizi, Fakultas Kesehatan Masyarakat, Universitas Jember, Indonesia.
E-mail: fanikh2001@gmail.com
[2] Program Studi Gizi, Fakultas Kesehatan Masyarakat, Universitas Jember, Indonesia.
E-mail: liristadyah@unej.ac.id

***Correspondence Author:**
Program Studi Gizi, Fakultas Kesehatan Masyarakat Universitas Jember, Jl. Kalimantan Kampus Bumi Tegal No.I/93, Krajan Timur, Boto, Kec. Sumbersari, Kabupaten Jember, Jawa Timur 68121, Indonesia.
E-mail: liristadyah@unej.ac.id

Article History:
Received: August 24, 2023; Revised: November 08, 2023; Accepted: December 17, 2023; Published: June 13, 2024.

Publisher:
Politeknik Kesehatan Aceh
Kementerian Kesehatan RI

Abstract

Obesity is a chronic low-grade inflammatory condition that occurs in the White Adipose Tissue (WAT). Diet is the strongest factor regulating energy balance and influencing inflammatory responses in the body. This inflammatory response can be calculated using the Dietary Inflammatory Index (DII). The aim of this research was to determine the differences between DII values for obese and non-obese people in the work area of the Sumbersari Public Health Center, Jember Regency, which was carried out from May to June 2023. This was a cross-sectional study with sample selection through a simple random sampling method. Thirty participants were included in each group. Data collection was carried out using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ), and the data were analyzed using an independent t-test. The normality test was performed using the Kolmogorov-Smirnov test, and the data were normally distributed. The results obtained that There was a significant difference (p=0,000) between the DII values of the normal and obese groups. It is known that the average DII value in the normal group was +2,29 and in the obese group was +1,32, indicating that the normal group had a higher pro-inflammatory diet than the obesity group. In conclusion, there was a significant difference between the DII values in obese and non-obese groups in the working area of the Sumbersari Community Health Center, Jember Regency.

Keywords: DII, obesity, inflammation

Abstrak

Obesitas merupakan suatu kondisi inflamasi kronik tingkat rendah yang terjadi pada *White Adipose Tissue* (WAT). Diet merupakan faktor yang paling kuat dalam mengatur keseimbangan energi serta mempengaruhi adanya respon inflamasi dalam tubuh. Respon inflamasi tersebut dapat dihitung dengan menggunakan sebuah parameter yang disebut DII (*Dietary Inflammatory Index*). Tujuan penelitian ini adalah mengetahui perbedaan antara nilai DII pada obesitas dan non-obesitas yang berada di wilayah kerja Puskesmas Kecamatan Sumbersari Kabupaten Jember yang dilaksanakan pada bulan Mei sampai Juni tahun 2023. Penelitian ini merupakan jenis penelitian *cross sectional* dengan pemilihan sampel melalui *simple random sampling.* Dihasilkan sejumlah 30 responden pada masing-masing kelompok. Metode pengambilan data dilakukan dengan wawancara menggunakan *Semi Quantitative Food Frequency Questionnaire* (SQ-FFQ) yang selanjutnya, data dianalisis menggunakan I*ndependen T-test*. Uji kenormalan menggunakan *Kolmogorov Smirnov* menghasilkan bahwa data berdistribusi normal. Hasil yang didapatkan menunjukkan terdapat perbedaan

yang signifikan (p=0,000) antara nilai DII kelompok normal dan obesitas. Diketahui rata-rata nilai DII pada kelompok normal +2,29 dan pada kelompok obesitas +1,32, nilai tersebut menunjukkan bahwa kelompok normal memiliki diet dengan pro-inflamasi yang lebih tinggi dibandingkan kelompok obesitas. Kesimpulan didapatkan bahwa terdapat perbedaan yang signifikan antara nilai DII pada kelompok obesitas dan non-obesitas di wilayah kerja Puskesmas Sumbersari Kabupaten Jember.

Kata Kunci: DII, obesitas, inflamasi

Introduction

Obesity is a complex multifactorial event caused by excessive fat accumulation that can pose serious health risks (WHO, 2022). Obesity is also known as a chronic, low-grade inflammatory condition that occurs in White Adipose Tissue (WAT) and can cause several metabolic diseases (Hildebrandt et al., 2023). Obesity is determined using anthropometric calculation indicators, such as Body Mass Index (BMI) and measurements of abdominal circumference/waist circumference. Obesity has been identified as an alarming global public health problem and a contributing factor to disability and death (WHO, 2022). In addition, an increase in the prevalence of obesity will result in a decline in health status and worry about the occurrence of metabolic effects in the form of Non-Communicable Diseases (NCD) (Banerjee & P., 2012).

Based on WHO data for 2021, the incidence of obesity worldwide has almost tripled since 1975. In 2016, 13% of the adults worldwide were obese. Meanwhile in Indonesia, nationally it is known that the prevalence of obese adults from 2007 to 2018 has increased from 10,5% to 21,8% (Riskesdas, 2018). Data from 2018 in East Java Province also showed a high incidence of obesity among those aged over 18 years (22,37 %). (Riskesdas Provinsi Jawa Timur, 2018). The same thing also happened in the Jember Regency, namely that the incidence of obesity was included in the ranking of the top 10 non-communicable diseases, with 3,215 men and 5,107 women in new cases of obesity in 2018 (Dinkes Jember, 2018).

The increase in cases of obesity will increase the risk of chronic diseases, such as heart disease, hypertension, stroke, diabetes, and cancer, which are the main causes of death in Indonesia (PMK RI No. 41 tahun 2014). Several risk factors can influence the occurrence of overweight and obesity, including diet, physical activity, genetics, surrounding environment, psychology, and socio-economic status (Chung et al., 2014; Hemmingsson, 2018). It is known that there are several foods that are thought to trigger an inflammatory response and there are other foods that are thought to reduce the inflammatory response in the body. Foods that contain magnesium, fiber, polyunsaturated fatty acids (PUFA), monounsaturated fatty acids (MUFA), omega-3, flavonoids, and carotenoids have anti-inflammatory properties, while foods that contain saturated fatty acids, trans fatty acids, carbohydrates with high glycemic index values, and high omega-6 to omega-3 are types of food with pro-inflammatory properties (Aghababayan et al., 2020).

Inflammation is a natural mechanism for maintaining homeostasis in the body owing to incoming foreign compounds. The occurrence of inflammation in the body is specifically related to nutrients in the diet; for example, a Mediterranean diet rich in fruits and vegetables is associated with low levels of inflammatory markers, whereas a diet rich in fats and simple carbohydrates is associated with high levels of inflammatory markers and may increase the risk of obesity, type 2 diabetes, and cardiovascular disease (Corley et al., 2019). Foods that are associated with inflammation in individuals are associated with early markers of cardiovascular diseases, such as hypertension, high plasma triglycerides, and lower levels of high-density lipoprotein (HDL) and cholesterol (Muhammad et al., 2019). The inflammatory properties of foods in the diet can be calculated using a parameter called DII (Dietary Inflammatory Index).

The Dietary Inflammatory Index is a tool designed to evaluate an individual's diet regarding inflammation to assess the overall inflammatory potential of foods. The resulting DII value is a parameter that categorizes individual food intake from anti-inflammatory to proinflammatory. The DII was calculated based on 45 food ingredient parameters from the SQ-FFQ (Shivappa et al., 2014). A study conducted

on non-diabetic Caucasian outpatients with obesity showed a link between obesity and the occurrence of chronic inflammation (Stępień et al., 2014). In another study conducted in Spain that aimed to assess the effect of the traditional Me-Diet on the primary prevention of CVD, higher DII values were associated with the incidence of obesity after controlling for the effect of diet adherence on inflammation (Ruiz-Canela et al., 2015). Meanwhile, in a research conducted on normal and obese adults in the urban area of Jakarta, excluding respondents with a diagnosis of PTM, it was concluded that there was no difference between the DII values in the two groups (Priskila et al., 2021).

The differences in several studies that have been carried out regarding the differences in DII values in normal and obese groups can provide an understanding that the dietary pattern factors adopted by a group of people in an area and the history of disease in an individual can influence the results of the inflammatory index obtained because they are closely related. according to the eating habits of certain ethnicities. Therefore, this study aimed to determine the difference between DII values in people with normal nutritional status and those with healthy obesity in the working area of the Sumbersari District Health Center, Jember Regency.

Methods

The type of research used in this study was cross-sectional research with a comparative design that aimed to compare DII values in obese and non-obese individuals.

This research was conducted from May to June 2023 at Posbindu activities in the work area of the Sumbersari District Health Center, Jember Regency. This research has undergone Ethical testing was performed at the Health Research Ethics Commission (HREC) and was declared to have met ethical principles and could be carried out with ethical number No.1983UN25.8/KEPK/DL/2023.

The samples in this study were individuals with obese and non-obese nutritional status in the age category of 20 to 59 years who lived in Sumbersari District, Jember Regency, and met the inclusion criteria and exclusion criteria for respondents diagnosed with non-communicable disease medical conditions. The sample was obtained using a simple random sampling method and calculated based on the aim of comparing the independent variables and the dependent variable; the total number of respondents in the obese and non-obese groups was 60 using the sample formula according to Dahlan (2005):

$$N1 = N2 = 2\ \frac{((\mathrm{Z}\alpha + \mathrm{Z}\beta)(\mathrm{S}))^2}{(X_1 - X_2)^2}$$

$$= 2\ \frac{((1{,}64+1{,}28)(2{,}91))^2}{(2{,}34)^2}$$

= 26,4 (Rounded up to 27 then added with a dropout value of 10% resulting in a total of 30 respondents)

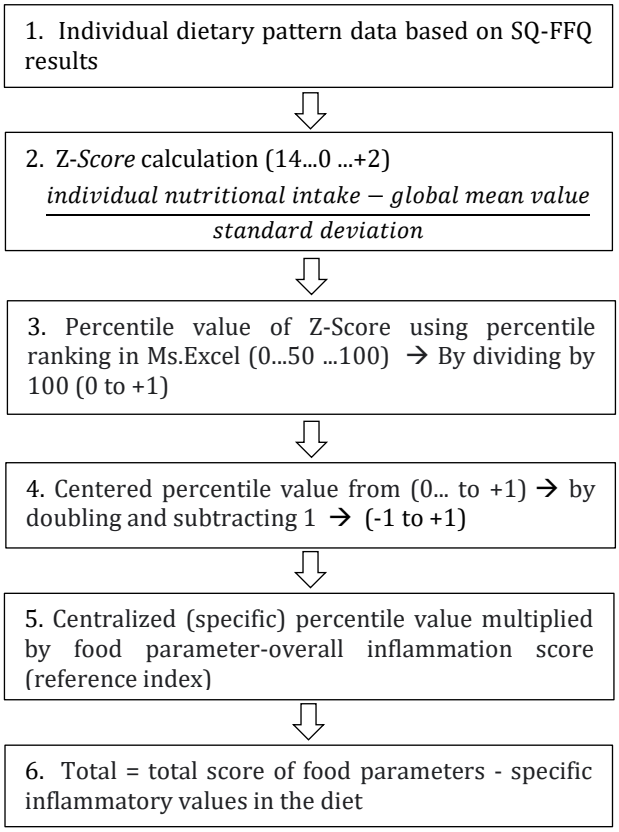
Information:

N : Large sample
Zα : Alpha standard derivative (1,64)
Zβ : Beta standard derivative (1,28)
S : Combined standard deviation
X_1-X_2 : The minimum difference between the means that is considered meaningful

The type of data obtained was primary data, which included the results of SQ-FFQ interviews, anthropometric parameters, and secondary data, including data on PTM surveillance in Sumbersari District, Jember Regency. In this study, individual food intake from the SQ-FFQ was calculated using 18 nutrient parameters from the NutriSurvey application. The nutrient parameters in this study included energy, protein, fat, carbohydrates, fiber, PUFA, cholesterol, vitamin A, beta-carotene, vitamin E, vitamin B1, vitamin B2, vitamin B6, vitamin B9, vitamin C, Fe, Mg, and Zn.

The data obtained were analyzed using univariate and bivariate analyses. A univariate analysis was performed to determine the distribution and frequency of each variable. Bivariate analysis was carried out using the Independent T-test statistical test to determine the difference between the independent variable and the dependent variable, namely the DII value and nutritional status of obese and non-obese respondents. Previously, a normality test was carried out on the data using the Kolmogorov–Smirnov test, and it was found that the data had a normal distribution or p value> 0,05. Furthermore, a homogeneity test was also carried out on the data variance using the Lavene test with a p-value of 0,208, which

means that the variances of the two groups were the same, so a T test was carried out for equal variances. The DII value was calculated based on the research conducted by San et al. (2018), as shown in the image below:



Picture 1. DII calculation steps

Result and Discussion

Tabel 1. Characteristics of Research Respondents

Characteristics	Nutritional Status			
	Normal		Obesity	
	n	%	n	%
Gender				
Man	3	10,0	2	6,7
Woman	27	90,0	28	93,3
Level of Education				
Elementary School	8	26,7	3	10,0
Secondary School	18	60	18	60
Studying at university	4	13,4	9	29,9
Type of Work				
Private Civil Servants	0	0,0	2	6,6
Self-employed	4	13,3	1	3,3
Laborer	1	3,3	1	3,3
Doesn't work	25	83,3	26	86,7

Characteristics	n	Mean±SD	n	Mean±SD
Age (year)	30	50,50±11,81	30	52,50±9,18
Parameter Anthropometrics				
Weight (kg)	30	51,85±6,51	30	65,69±8,99
Height (cm)	30	152,88±6,71	30	152,50±7,07
Abdominal circumfeence (cm)	30	80,30±7,85	30	86,77±8,94
Percent Fat (%)	30	29,51±4,59	30	36,79±4,01
Anthropometric Index				
BMI (kg/m^2)	30	22,08±2,06	30	28,28±2,76

Based on the results obtained, it is known that the majority of respondents in both groups were female; in the normal group, there were 27 people (90,0%), and in the obese group, 28 people (93,3%). This is in line with the results of research conducted by Salam (2020) and Dyah et al. (2022) that the majority of those who visit the Posbindu Jember Regency are female. This is based on several theories that state that women are more sensitive to the health problems they experience, so that they use health services more often to maintain their health (Astriani et al., 2021). Septiyanti and Seniwati (2020) showed that more women are obese than men because they generally do not work, so a lack of physical activity can cause obesity. This is also in line with the results of data from Riskesdas in 2018, where the obesity rate in women was higher than that in men (44,4% and 26,6%, respectively).

It is known that the majority of respondents in this study received final education up to secondary school, namely, 18 people in the normal group (60%) and 18 people in the obese group (60%). The level of education can influence food consumption by choosing daily food. A lower level of education of an individual will lead to lower awareness of the food chosen; namely, the food chosen tends to be just full without prioritizing the balance of nutrients in food intake, which is in accordance with the body's needs (Puspitasari, 2018).

Data regarding respondents' occupations showed that the majority of respondents in both groups did not work, including those who had retired from their jobs or had chosen to become housewives. In the normal group, 25 people did not work (83,3%), and in the obese group, 26 people did not work (86,7%), People who do not work do more of their activities at home, so they tend to expend less energy in their bodies than people who work outside home. Research on

risk factors for obesity in housewives also explains that physical activity is a risk factor for obesity (Abdullah, 2019; Apriaty & Nuryanto, 2015). A high amount of food intake that is not accompanied by sufficient physical activity increases the risk of accumulating body fat, which over time will cause obesity (Puspitasari, 2018). Housewives with low physical activity have a 5,5 times higher risk than those with high physical activity (Abdullah, 2019).

In this study, respondents in the normal group had an average age of 50,5 years, whereas respondents in the obese group had an average age of 52,5 years, The limits for the adult age category according to the WHO are 20–59 years, while ages 30–49 years and >50 years are classified as middle age (Kemenkes, 2017). It is known that there is a relationship between age and the incidence of obesity; an increase in age causes an increase in the incidence of obesity due to an increase in total body fat content, especially in the distribution of central fat (Puspitasari, 2018). Apart from that, as you age, you will experience a decrease in muscle mass and changes in several body hormones that trigger the accumulation of belly fat.

The anthropometric parameter data produced in this study included body weight, height, abdominal circumference, and fat percentage. The average body weight of the obese group was higher than that of the normal group, namely 65,69 kg and 51,85 kg. while the average height in the normal group was 152,88 cm and 152,50 cm in the obese group. Based on the results of this study, the average abdominal circumference in the normal group was 80,30 cm and that in the obese group was 86,77 cm. According to the 2014 Republic of Indonesia Minister of Health Regulation, the limit value for abdominal circumference classified as obese is ≥90 cm in men and ≥80 cm in women. In research results related to fat percentage, it is known that the average fat percentage in the normal group is 29,5% and the average fat percentage value in the obese group is 36,7%. According to the American Council on Exercise, the classification of body fat percentage is within the normal range of 25–30%. From the anthropometric index data of respondents, the average BMI measurement result in the normal group was 22,08 and in the obese group, it was 28,28. According to the 2014 Indonesian Minister of Health Regulation regarding BMI classification, the normal BMI value is in the range of 18,5 to 25,0, while the BMI value for obesity is >25,0.

DII Values of Obese and Non-Obetic Respondents

Table 2. Overall DII score results

	Nutritional Status (BMI*)	
DII	Normal	Obesity
Mean	2,29	1,32
Median	2,18	1,47
Std. Deviation	0,74	1,00
Min.	0,36	-1,72
Max.	3,38	2,65

**Data in units DII*

Based on the results of research that has been carried out, it is known that the average DII value in the normal group is +2,29 and in the obese group is +1,32. In research conducted by García-Calzón et al (2015) It is known that the value -5,97 is a DII value which is considered a strong anti-inflammatory, while a value of +3,91 is a DII value which is considered a strong pro-inflammatory. In addition, in research conducted on young people in Spain using 45 food parameters, it was found that based on the frequency and amount of intake of various foods, the overall diet results could provide values in the range of -8,87 (maximum anti-inflammatory) to +7,98 (maximum pro-inflammatory) (Andrade et al., 2019). Based on the average DII value produced in this study, it is known that respondents in the obese group had a higher intake of anti-inflammatory components than those in the normal group, such as fiber, PUFA, vitamin A, vitamin E, carotene, vitamin B1, vitamin B2, vitamin B6, and vitamin B9. A more positive DII value indicates a more pro-inflammatory diet, while a more negative DII value indicates a more anti-inflammatory diet (Muhammad et al., 2019). A pro-inflammatory diet is associated with several types of nutritional intake, including energy, carbohydrate, protein, total fat, trans-fat, Saturated Fatty Acid (SAFA), cholesterol, iron, and vitamin B12 (Luglio Muhammad et al., 2019; Priskila et al., 2021; Utami et al., 2020). Other studies have shown that factors related to inflammation include high amounts of saturated fat and trans fat, and low amounts of fiber and vitamins. In addition, flavonoids from fast foods are the main contributors to the proinflammatory value. In contrast, a combination of greater amounts of vegetables,

fruits, and whole grains in the Mediterranean diet and a meal plan high in macrobiotics appears to have the potential to boost the anti-inflammatory value of the diet (Shivappa et al., 2014). Other factors that also influenced the incidence of obesity in this study were gender, the fact that the majority of respondents did not work, the influence of hormones in the respondent's age group that triggered fat accumulation, and the knowledge and awareness possessed by the respondents.

A more pro-inflammatory diet is known to be a factor that can activate inflammatory reactions in the body, which is also related to metabolic disorders; therefore, the daily consumption of anti-inflammatory foods, such as vegetables and fruits, is very important to suppress inflammatory reactions in the body. This is because vegetables and fruits contain antioxidants, which can contribute to an anti-inflammatory diet in the body. A higher vegetable and fruit intake is associated with lower levels of oxidative stress and inflammation. This is because the addition of antioxidants can limit or reverse the pro-inflammatory response in foods with a high saturated fatty acid content (Kiecolt-Glaser, 2010). In addition, according to a study conducted by the New York Gastroenterology Associates, fiber intake has a high anti-inflammatory value because fiber can feed the microbiome in the intestine. When the body provides sufficient fiber intake for bacteria in the intestine, it forms a very anti-inflammatory component called Short-Chain Fatty Acid. The more the body provides fiber intake for bacteria in the intestine, the greater the production of anti-inflammatory components will be produced (Shivakoti et al., 2022).

Comparison of DII Values for Obese and Non-Obetic Respondents

Table 3. Comparison of obesity and non-obesity DII values

Nutritional Status (IMT*)	Value DII			T-test		
	n	Mean ± SD	Mean dif. ± SD	lower	upper	P
Normal	30	2,29 ± 0,74	0,97 ± 0,23	0,52	1,43	<0,001**
Obesity	30	1,32 ± 1,00				

**Data in units*

***Significance <0,05*

The results of the normality test (p=0,074) and homogeneity (p=0,208), then the DII value was tested using the independent t-test, and the result was p<0,001, which means there was a significant difference between the average DII value in the normal group and the obese group. The average DII value in the normal group was +2,29, whereas that in the obese group was +1,32. The DII value in the normal group was higher, which means that it leads to stronger pro-inflammation than the DII value in the obese group. The stronger pro-inflammatory effect shown by the group of normal respondents compared with the group of obese respondents was because most of the obese group in this study had made changes to their diet, one of which was choosing the food they consumed to be better and healthier. This was based on interviews with the respondents using the SQ-FFQ. Another factor could be the low reporting of social desires among obese respondents. This study showed that the intake of fiber, PUFA, vitamin A, vitamin E, carotene, vitamin B1, vitamin B2, vitamin B6, and vitamin B9 was higher in the obese group than in the non-obese group. Priskila et al. (2021) explained that the obese group in this study had higher awareness, thus influencing their eating patterns compared to the normal group. The obese group in this study tended to consume more fiber, vitamins, and mineral components, such as vegetables and fruits, which have high anti-inflammatory properties and are good at suppressing pro-inflammatory properties in the body. This was also shown by the results of anti-inflammatory intake in the obese group, which was higher than that in the normal group in this study. It is known that the fiber intake of respondents in the normal group was 7,23 g and that in the obese group was 12,84 g. The fiber intake in the obese group was higher than that in the normal group, thus allowing for a stronger pro-inflammatory suppression mechanism in the obese group than in the normal group (Vinolo et al., 2011).

These results are in line with research showing that the DII value in the normal group is actually more pro-inflammatory than that in the

obese group (Priskila et al., 2021). This could be due to their high awareness and lack of reporting regarding social desires among obese respondents, causing their low calorie intake. As explained by Aulia and Yulianti (2018), weight control is one of the factors that influence food choices. Additionally, Ritan et al. (2018) found that the majority of students with an obese nutritional status experience dissatisfaction with their body shape because they are too fat and unsightly, so they tend to limit the amount of food they eat to reduce body weight. This illustrates that positive or negative body perceptions can influence an individual's eating patterns.

The DII value is closely related to the amount and type of food consumed by the individual. Meanwhile, obesity can increase inflammatory mediators in the body (Ellulu et al., 2016). Obesity is a predisposition to pro-inflammation through an increase in IL-6 and TNF-α mediators as well as a decrease in adiponectin levels, which have an anti-inflammatory function in the body. Being obese or overweight at an early age can cause various chronic diseases, such as diabetes, cancer, and CVD in the future. Therefore, consuming a diet with high anti-inflammatory properties, such as more vegetables and fruits, rich in fiber, flavonoids, zinc, magnesium, and selenium, can support healthy body weight (Vahid et al., 2020).

The limitations of this study relate to the failure to control for male and female respondents because women dominate the posbindu members in the Sumbersari sub-district, so the numbers do not allow for control.

Conclusion

There was a difference in DII values between the normal and obese groups. The mean DII value in the normal group was more positive than that in the obese group.

The results of this study suggest that it is necessary to provide education and counseling regarding the relationship between food and inflammation to make it easier for people to choose foods with an anti-inflammatory response.

References

Abdullah, M. (2019). Faktor-faktor yang berhubungan dengan kejadian obesitas pada ibu rumah tangga di Desa Tibang Banda Aceh. *Journal Of Healthcare Technology And Medicine*, *5*(1), 200–209. https://doi.org/10.33143/jhtm.v5i1.1027

Aghababayan, S., Mobarakeh, Z. S., Qorbani, M., Tiznobeyk, Z., Aminianfar, A., & Sotoudeh, G. (2020). Higher dietary inflammatory index scores are associated with increased odds of benign breast diseases in a case–control study. *Journal of Inflammation Research*, *13*, 61–69. https://doi.org/10.2147/JIR.S232157

Andrade, P. A., Hermsdorff, H. H. M., Leite, J. I. A., Shivappa, N., Hébert, J. R., Henriques, H. K. F., & de Oliveira Barbosa Rosa, C. (2019). Baseline pro-inflammatory diet is inversely associated with change in weight and body fat 6 months following-up to bariatric surgery. *Obesity Surgery*, *29*(2), 457–463. https://doi.org/10.1007/s11695-018-3530-3

Apriaty, L., & Nuryanto, N. (2015). Faktor risiko obesitas ibu rumah tangga di Kelurahan Bendungan Kecamatan Gajahmungkur Kota Semarang. *Journal of Nutrition College*, *4*(4), 443–449. https://doi.org/10.14710/jnc.v4i4.10144

Astriani, A., Syafar, M., & Azis, R. (2021). Hubungan faktor perilaku dengan kunjungan lansia di Posbindu Lansia. *Jurnal Ilmiah Kesehatan Sandi Husada*, *10*(2), 452–461. https://doi.org/10.35816/jiskh.v10i2.630

Aulia, L., & Yulianti, L. N. (2018). Faktor keluarga, media, dan teman dalam pemilihan makanan pada mahasiswa PPKU IPB. *Jurnal Ilmu Keluarga & Konsumen*, *11*(1), 37–48. https://doi.org/10.24156/jikk.2018.11.1.37

Banerjee, A., & P., D. (2012). Comorbidities of childhood obesity. In *Childhood Obesity*. InTech. https://doi.org/10.5772/33612

Chung, A., Backholer, K., Wong, E., Palermo, C., Keating, C., & Peeters, A. (2014). Trends in child and adolescent obesity prevalence according to socioeconomic position: Protocol for a systematic review. *Systematic Reviews*, *3*(1). https://doi.org/10.1186/2046-4053-3-52

Corley, J., Shivappa, N., Hébert, J. R., Starr, J. M., &

Deary, I. J. (2019). Associations between Dietary Inflammatory Index Scores and Inflammatory Biomarkers among older adults in the Lothian Birth Cohort 1936 study. *Journal of Nutrition, Health and Aging*, *23*(7), 628–636. https://doi.org/10.1007/s12603-019-1221-y

Dyah, L., Oktafiani, A., Mufida Ersanti, A., & Munawaroh Aziz, A. (2022). Screening penyakit tidak menular dan edukasi cardiopulmonary resucitation di Desa Kranjingan Kecamatan Sumbersari, Kabupaten Jember. *Public Health, University of Jember in Collaboration with PERSAKMI ABDIMAYUDA*, 55–59. https://doi.org/10.19184/abdimayuda.v%vi%i.28536

Ellulu, M. S., Khaza'ai, H., Rahmat, A., Patimah, I., & Abed, Y. (2016). Obesity can predict and promote systemic inflammation in healthy adults. *International Journal of Cardiology*, *215*, 318–324. https://doi.org/10.1016/j.ijcard.2016.04.089

García-Calzón, S., Martínez-González, M. A., Razquin, C., Corella, D., Salas-Salvadó, J., Martínez, J. A., Zalba, G., & Marti, A. (2015). Pro12Ala polymorphism of the PPARγ2 gene interacts with a mediterranean diet to prevent telomere shortening in the PREDIMED-NAVARRA randomized trial. *Circulation: Cardiovascular Genetics*, *8*(1), 91–99. https://doi.org/10.1161/circgenetics.114.000635

Hemmingsson, E. (2018). Early childhood obesity risk factors: Socioeconomic adversity, family dysfunction, offspring distress, and junk food self-medication. In *Current obesity reports* (Vol. 7, Issue 2, pp. 204–209). https://doi.org/10.1007/s13679-018-0310-2

Hildebrandt, X., Ibrahim, M., & Peltzer, N. (2023). Cell death and inflammation during obesity:"Know my methods, WAT (son)." *Cell Death & Differentiation*, *30*(2), 279–292. https://doi.org/10.1038/s41418-022-01062-4

Kiecolt-Glaser, J. K. (2010). Stress, food, and inflammation: Psychoneuroimmunology and nutrition at the cutting edge. *Psychosomatic Medicine*, *72*(4), 365. https://doi.org/10.1097/PSY.0b013e3181dbf489

Luglio Muhammad, H. F., van Baak, M. A., Mariman, E. C., Sulistyoningrum, D. C., Huriyati, E., Lee, Y. Y., & Wan Muda, W. A. M. (2019). Dietary Inflammatory Index score and its association with body weight, blood pressure, lipid profile, and leptin in indonesian adults. *Nutrients*, *11*(1). https://doi.org/10.3390/nu11010148

Priskila, L. Y., Agustina, R., Djuwita, R., Permadhi, I., Abdullah, F. W. M., & Prafiantini, E. (2021). Association between Dietary Inflammatory Index and Serum Tumor Necrosis Factor Alpha Level in Adult with Normal and Obese Body Mass Index in Jakarta. *International Journal of Innovative Sciece and Research Technology*, *6*(11), 906–916. https://lib.ui.ac.id/detail?id=20514218&lokasi=lokal

Puspitasari, N. (2018). Kejadian obesitas sentral pada usia dewasa. *HIGEIA (Journal of Public Health Research and Development)*, *2*(2), 249–259. https://doi.org/10.15294/higeia.v2i2.21112

Ritan, A. F. G., Murdhiono, W. R., & Syafitri, E. N. (2018). Hubungan body image dengan pola makan dan aktivitas fisik pada mahasiswa obesitas di Fakultas Ilmu Kesehatan Universitas Respati Yogyakarta. *Ilmu Gizi Indonesia*, *2*(1), 25–32. https://doi.org/10.35842/ilgi.v2i1.85

Ruiz-Canela, M., Zazpe, I., Shivappa, N., Hébert, J. R., Sánchez-Tainta, A., Corella, D., Salas-Salvadó, J., Fitó, M., Lamuela-Raventós, R. M., Rekondo, J., Fernández-Crehuet, J., Fiol, M., Santos-Lozano, J. M., Serra-Majem, L., Pinto, X., Martínez, J. A., Ros, E., Estruch, R., & Martínez-González, M. A. (2015). Dietary inflammatory index and anthropometric measures of obesity in a population sample at high cardiovascular risk from the PREDIMED (PREvención con DIeta MEDiterránea) trial. *British Journal of Nutrition*, *113*(6). https://doi.org/10.1017/S0007114514004401

San, K. M. M., Fahmida, U., Wijaksono, F., Lin, H., Zaw, K. K., & Htet, M. K. (2018). Chronic low-grade inflammation measured by

dietary inflammatory index and its association with obesity among school teachers in Yangon, Myanmar. *Asia Pacific Journal of Clinical Nutrition*, *27*(1), 92–98. https://doi.org/10.6133/apjcn.042017.06

Septiyanti, S., & Seniwati, S. (2020). Obesity and central obesity in Indonesian urban communities. *Jurnal Ilmiah Kesehatan (JIKA)*, *2*(3), 118–127. https://doi.org/10.36590/jika.v2i3.74

Shivakoti, R., Biggs, M. L., Djoussé, L., Durda, P. J., Kizer, J. R., Psaty, B., Reiner, A. P., Tracy, R. P., Siscovick, D., & Mukamal, K. J. (2022). Intake and Sources of Dietary Fiber, Inflammation, and cardiovascular disease in Older US Adults. *JAMA Network Open*, *5*(3), e225012. https://doi.org/10.1001/jamanetworkopen.2022.5012

Shivappa, N., Steck, S. E., Hurley, T. G., Hussey, J. R., & Hébert, J. R. (2014). Designing and developing a literature-derived, population-based dietary inflammatory index. *Public Health Nutrition*, *17*(8), 1689–1696. https://doi.org/10.1017/S1368980013002115

Stępień, M., Stępień, A., Wlazeł, R. N., Paradowski, M., Banach, M., & Rysz, J. (2014). Obesity indices and inflammatory markers in obese non-diabetic normo- and hypertensive patients: a comparative pilot study. *Lipids in Health and Disease*, *13*(1), 29. https://doi.org/10.1186/1476-511X-13-29

UTami, S. C., Dieny, F. F., Kusumastuti, A. C., & Tsani, A. F. A. (2020). Association of Dietary Inflammatory Index with Visceral Adiposity Index among obese female adolescents. *International Journal of Pharmaceutical Research (09752366)*, *12*(3).

Vahid, F., Bourbour, F., Gholamalizadeh, M., Shivappa, N., Hébert, J. R., Babakhani, K., Mosavi Jarrahi, A., Mirzaei Dahka, S., & Doaei, S. (2020). A pro-inflammatory diet increases the likelihood of obesity and overweight in adolescent boys: A case-control study. *Diabetology and Metabolic Syndrome*, *12*(1). https://doi.org/10.1186/s13098-020-00536-0

Vinolo, M. A. R., Rodrigues, H. G., Nachbar, R. T., & Curi, R. (2011). Regulation of inflammation by short chain fatty acids. In *Nutrients* (Vol. 3, Issue 10, pp. 858–876). MDPI AG. https://doi.org/10.3390/nu3100858

WHO. (2022). *WHO European regional obesity report 2022*. World Health Organization. Regional Office for Europe. https://apps.who.int/iris/bitstream/handle/10665/353747/9789289057738-eng.pdf