



The Relationship between Consumption Patterns of Macronutrients, Fiber, and Physical Activity with the Incidence of Obesity at Nuris Jember High School

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ARTICLE INFO

Article history:

Received 27 July 2024
Accepted 29 September 2024
Published 4 October 2024

Keyword:

Macronutrient Consumption Patterns
Physical Activity
Adolescents
Obesity

ABSTRACT

Obesity is one of the global health problems whose incidence is expected to continue to increase every year. Obesity in adolescents is caused by many factors including changes in lifestyle, physical activity, diet with food intake that exceeds the body's needs, improper eating behavior by consuming more fast food, packaged food, and food with unbalanced nutrients. The purpose of this study was to determine the relationship between macronutrient diet, fiber, and physical activity with the incidence of obesity at Nuris Jember High School. This method is an observational study with a case-control design. Sample selection using purpose sampling of as many as 81 respondents consisting of 27 cases and 54 controls. The research instruments used were weight measurement, height, SQ-FFQ form, and PAL. Data were processed using statistical applications using the chi-square test and if not eligible, the Fisher's exact test was performed with a significant value of $p < 0.005$. The results of macronutrient consumption patterns and physical activity have a significant relationship with the incidence of obesity ($p < 0.005$). While the study could not analyze fiber consumption patterns due to homogeneous results, the existing findings provide a solid foundation for targeted nutrition education programs and public health strategies. This study concludes that there is a relationship between macronutrient consumption patterns and physical activity with the incidence of obesity. This conclusion underscores the importance of balanced diets and regular physical activity in preventing and managing obesity among adolescents.

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Kata kunci:

Pola Konsumsi makronutrien
aktivitas fisik
remaja
Obesitas

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DOI: [10.47679/makein.2024209](https://doi.org/10.47679/makein.2024209)

ABSTRAK

Obesitas merupakan salah satu masalah kesehatan global yang angka kejadiannya diperkirakan akan terus meningkat setiap tahunnya. Obesitas pada remaja disebabkan karena banyak faktor antara lain adalah perubahan gaya hidup, aktivitas fisik, pola makan dengan asupan makan yang melebihi dari kebutuhan tubuh, perilaku makan tidak tepat dengan lebih banyak mengonsumsi makanan cepat saji, makanan di dalam kemasan, dan makanan dengan zat gizi yang tidak seimbang. Tujuan dari penelitian ini adalah untuk mengetahui hubungan anatara pola makan zat gizi makro, serat, dan aktivitas fisik dengan kejadian obesitas di SMA Nuris Jember. Metode ini merupakan penelitian observasional dengan desain case control. Pemilihan sampel menggunakan purpose sampling sebanyak 81 responden terdiri dari 27 kasus dan 54 kontrol. Instrumen penelitian yang digunakan adalah pengukuran berat badan, tinggi badan, formulir SQ-FFQ, dan PAL. Data diolah menggunakan aplikasi statistik menggunakan uji chi-square dan apabila tidak memenuhi syarat dilakukan uji fisher's exact dengan nilai signifikan $p < 0,005$. Hasil pola konsumsi zat gizi makro dan aktivitas fisik memiliki hubungan yang signifikan dengan kejadian obesitas ($p < 0,005$). Meskipun penelitian ini tidak dapat menganalisis pola konsumsi serat karena hasil yang homogen, temuan yang ada memberikan landasan yang kuat untuk program pendidikan gizi yang

ditargetkan dan strategi kesehatan masyarakat. Penelitian ini menyimpulkan terdapat hubungan pola konsumsi makronutrien dan aktivitas fisik dengan kejadian obesitas. Kesimpulan ini menggarisbawahi pentingnya pola makan seimbang dan aktivitas fisik teratur dalam mencegah dan mengelola obesitas di kalangan remaja.

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INTRODUCTION

Obesity is one of the global health problems whose incidence is expected to continue to increase every year. The incidence of obesity in 2020 reached 38% of the world population and is expected to be more than 50% by 2035 (World Obesity Federation, 2023) and Indonesia has an obesity incidence rate of 21.8% in 2018. East Java is one of the provinces in Indonesia where the percentage of obesity is quite high at 16%, obesity cases in Jember amounted to 10.65% (Susindra and Permatasari, 2023), and approximately one-third of them are obese in high school / equivalent adolescents, namely 3.1%. Preliminary studies based on data from the Jember Regency Health Office in 2022-2023, Summersari District is the district with the highest rate of adolescent obesity in Jember Regency, namely 178 out of 696 students netted or 25.57%, where this figure exceeds the incidence rate in Indonesia, and based on data from the Summersari health center, Nuris Jember High School (SMA) is the school with the fourth highest obesity rate at 10.06%.

SMA Nuris Jember is a pesantren-based school that has a dormitory. Students of SMA Nuris Jember reside in the pesantren so that all meals and activities are carried out in the pesantren and the diet follows the provisions set by the pesantren. However, students can get food from outside the pesantren such as parents' provisions and snacks in the canteen. Diet in pesantren in providing food ingredients is generally limited due to cost issues and results in the food menu provided may not be able to meet the nutritional needs of students. Research conducted by a previous study stated that the availability of food in pesantren is still below the daily needs of students in terms of energy, protein, fat, and carbohydrates (Febrianti et al., 2023). Nuris High School provides food for breakfast and afternoon meals, but for lunch, they can buy it in the school area so that to meet their nutritional needs they have to meet outside of pesantren meals, which can also have an impact on the uncontrolled consumption patterns of students they get from outside the pesantren.

Obesity in adolescents is caused by many factors, including changes in lifestyle, physical activity, diet with food intake that exceeds the body's needs, improper eating behavior by consuming more fast food, packaged food, and food with unbalanced nutrients (Mutia et al., 2022). As proposed by Cockerham, emphasizes the role of social determinants in shaping health behaviors. It suggests that lifestyle choices, including diet and physical activity, are influenced by social and environmental factors, which can contribute to obesity (Cockerham, 2022). The Fogg Behavior Model, for instance, highlights the need for motivation, ability, and prompts to facilitate behavior change. This model can be applied to promoting healthy dietary habits and regular physical activity (Fruh et al., 2021). UNICEF emphasizes the need to consider multiple factors affecting food access and quality. It promotes healthy diets by making nutritious food desirable, affordable, and accessible, and by regulating harmful food practices (Aguayo et al., 2020).

Digital tools and strategies can effectively promote healthy dietary and activity patterns, particularly in children and adolescents, by improving fruit and vegetable intake and encouraging regular physical activity (Lee et al., 2023). These theories and approaches collectively underscore the critical role of balanced diets, adequate fiber intake, and regular physical activity in preventing obesity. If obesity cases are not treated immediately, it will have an impact on health status and can reduce a person's quality of life because obesity can trigger several serious degenerative diseases such as cardiovascular disease, heart disease, stroke, hypertension, diabetes mellitus, cancer, until it is not uncommon to find cases of obesity as a cause of premature death (Susindra and Permatasari, 2023).

Nutrition in adolescents is very important because adolescent nutrition problems greatly affect growth and development and have an impact on nutrition problems in adulthood World Obesity Federation. (2023). Adolescent age, namely at the age of 10 to 18 years is a period of nutritional vulnerability because adolescents need higher amounts of nutrients due to increased physical growth and development, lifestyle changes, and different eating habits (Mutia et al., 2022). According to research conducted by Setiawati, 15 out of 18 people who were declared obese had a diet high in fat, sugar, and salt, low levels of physical activity, and bad habits of eating fast food. All of these factors have the potential to increase the incidence of obesity in adolescents (Saprudin et al., 2023). This is due to industrialization and migration that cause changes in diet, physical activity, and overall health. One of the causes of nutritional shifts that can lead to obesity is the increased availability of foods high in fat and sugar (Triyanti and Ardila, 2020).

Fiber intake can provide a longer satiety effect which results in limiting and reducing the amount of high-fat and high-energy food intake. According to research conducted by Purnamaningsih, et al., (2023) fiber consumption in adolescents is considered insufficient, which is 68.2%. This is because teenagers prefer fast food which has a bad impact on health. After all, it contains high fat, high calories, and low fiber. These factors cause adolescents to consume less fruits and vegetables as foods with a lot of fiber content (Purnamaningsih et al., 2023). The recommendation to consume high-fiber foods through fruits and vegetables is an action to reduce the risk of degenerative diseases (Kurniasanti, 2020). Several studies have shown that the consumption of adequate amounts of fiber can help maintain an ideal body weight and avoid the occurrence of degenerative diseases (Siregar and Rahmy, 2022). Physical activity can play a role in determining a person's health condition. Unbalanced energy expenditure compared to energy intake in the body can also cause fat deposition and increase the risk of overweight and obesity. The physical activity carried out regularly by adolescents can increase immunity, metabolic systems, and antibodies that can reduce the risk of contracting infectious diseases, degenerative diseases, and obesity (Aulia, *et.al.* 2022). Based

on this background, researchers want to further examine the relationship between macronutrient consumption patterns, fiber, and physical activity with the incidence of obesity at Nuris Jember High School. The findings of this study can be applied to health policies or intervention programs in schools or Islamic boarding schools.

METHOD

This type of research is quantitative research with a research design using a case-control design. This study analyzed the relationship between macronutrient consumption patterns, fiber, and physical activity with the incidence of obesity in Nuris Jember High School. The population in this study was 501 students of Nuris High School class with a sample size of 81 respondents consisting of 27 obese respondents (case) and 54 normal respondents (control). The sampling technique used was purpose sampling. The analysis used is univariate and bivariate.

This study used digital scales to measure body weight, microtoice to measure height, SQ-FFQ (Semi Quantitative Food Frequency Questionnaire) form to assess macronutrient and fiber consumption patterns, and PAL (Physical Activity Level) form to measure physical activity. The completion of the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) and Physical Activity Level (PAL) questionnaires was supervised to ensure data validity and reliability through trained interviewers, all interviewers were trained to ensure that the data collection process was standardized and reliable, and also we conducted Face-to-face interviews were used to collect data, which allowed for real-time clarification of any questions and ensured that respondents understood the questions correctly. Moreover, The SQ-FFQ was validated by experts from the Nutrition Department, Faculty of Public Health, Jember University, and a doctor in Nuris High School, who eliminated rarely consumed foods among students in boarding schools in Jember, making the questionnaire more suitable for the target population. Manual data was processed in several stages, editing or checking data, coding or making codes to make data simpler, entering or transferring data to Ms. Excel, and tabulating or creating tables that separate the tables of univariate analysis results and tables of bivariate results. Univariate analysis was used to explain the characteristics of each variable studied which were presented in tables with narratives. Dependent variables related to the incidence of obesity and independent variables related to macronutrient consumption patterns, fiber, and physical activity. The results of univariate analysis will provide an overview of the distribution and frequency of each variable. While bivariate analysis to determine whether there is a relationship between macronutrient consumption patterns, fiber, and physical activity with the incidence of obesity at Nuris Jember High School uses Chi-square test statistics and if it does not meet the Chi-square test requirements, then the Fisher's Exact Test is performed. This study has conducted ethical research at the Faculty of Dentistry, University of Jember with No. 36/UN25.8/KEPK/DL/2024.

RESULTS OF STUDY

This study has a total sample size of 81 respondents consisting of obese groups and normal groups with a ratio of

1: 2. The characteristics of respondents studied in this study include age and gender. The results of Table 1 show that the distribution of respondent characteristics at Nuris High School according to age was mostly 17 years old (55.6%) in the obesity group and 16 years old (55.6%) in the normal group. Characteristics according to gender in both groups were mostly female (85.2%). The results show that all respondents in both the obesity group and the normal group have insufficient fiber consumption (100%). The table above shows that the relationship between fiber intake and the incidence of obesity cannot be analyzed due to homogeneous results. The finding that all respondents in both groups have insufficient fiber consumption (100%) indicates a lack of variability in fiber intake. This homogeneity means that there are no differences in fiber consumption patterns between individuals with obesity and those without.

Table 1 Respondent Characteristics and Distribution and relationship of Fiber Intake (N=81)

Characteristics	Obesity		Normal	
	n	%	n	%
Individual Characteristics				
Age				
16 years	10	37	30	55,6
17 years	15	55,6	24	44,4
18 years	2	7,4	0	0
Gender				
Female	23	85,2	46	85,2
Male	4	14,8	8	14,8
Fiber Intake				
Less	27	100	54	100
Enough	0	0	0	0

The results of Table 2 show that the percentage of obese group respondents who had energy intake in the more category was 55.6%, while in the normal group, the majority had energy intake in the less category as much as 90.7%. The percentage of obese group respondents who had protein intake in the more category was 51.9%, while in the normal group, the majority had protein intake in the less category as much as 88.9%. The percentage of obese group respondents who had a fat intake with more categories was 44.4%, while in the normal group, the majority had a fat intake with fewer categories as much as 92.6%. The percentage of respondents in the obese group who had more carbohydrate intake was 66.7%, while in the normal group, the majority had sufficient and deficient carbohydrate intake of 48.1% respectively. Table 2 shows the relationship between macronutrients as evidenced by the p-value <0.005 from the Fisher's Exact Test statistical test results it can be concluded that there is a relationship between energy intake and the incidence of obesity, p-value <0.005 from the Fisher's Exact Test statistical test results it can be concluded that there is a relationship between protein intake and the incidence of obesity, p-value <0.005 from the Fisher's Exact Test statistical test results it can be concluded that there is a relationship between fat intake and obesity, p-value <0.005 from the Chi-square statistical test results it can be concluded that there is a relationship between carbohydrate intake and obesity.

Table 2 Distribution and relationship of Macronutrient Intake (Energy, Protein, Fat, and Carbohydrate) with the Incidence of Obesity

Macronutrient Intake	Obesitas		Normal		p-value
	n	%	n	%	
Energy					
More	15	55,6	1	1,9	0,000**
Enough	4	14,8	4	7,4	
Less	8	29,6	49	90,7	
Protein					
More	14	51,9	0	0	0,000**
Enough	6	22,2	6	11,1	
Less	7	25,9	48	88,9	
Fat					
More	12	44,4	0	0	0,000**
Enough	6	22,2	4	7,4	
Less	9	33,3	50	92,6	
Carbohydrate					
More	18	66,7	2	3,7	0,000*
Enough	3	11,1	26	48,1	
Less	6	22,2	26	48,1	
Total	27	100	54	100	

*there is a significant relationship p value <0.005 from the Chi-square statistical test results

**There is a significant relationship p value <0.005 from the results of the Fisher's Exact Test statistical test

Table 3. Frequency Distribution of Types of Foodstuffs Sources of Macronutrients (Energy, Protein, Fat, Carbohydrates) and Fiber with the Incidence of Obesity

Food Material	Obesity								Normal							
	Often		Rarely		Never		Total		Often		Rarely		Never		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Carbohydrates																
White Rice	27	100	0	0	0	0	27	100	54	100	0	0	0	0	54	100
Vermicelli	27	100	0	0	0	0	27	100	54	100	0	0	0	0	54	100
Corn	2	7,4	25	92,6	0	0	27	100	3	5,6	51	94,4	0	0	54	100
Potatoes	8	29,6	2	7,4	17	63	27	100	5	9,3	15	27,8	34	63	54	100
Taro	1	3,7	2	7,4	24	88,9	27	100	1	1,9	8	14,8	45	83,3	54	100
Protein																
Tempe	1	3,7	26	96,3	0	0	27	100	2	3,7	51	94,4	1	1,9	54	100
Tofu	26	96,3	1	3,7	0	0	27	100	53	98,1	0	0	1	1,9	54	100
Skipjack Fish	2	7,4	13	48,1	12	44,4	27	100	5	9,3	19	35,2	30	55,6	54	100
Tuna Fish	4	14,8	3	11,1	20	74,1	27	100	2	3,8	21	39,6	30	56,6	54	100
Squid	3	11,1	2	7,4	22	81,5	27	100	0	0	17	31,5	37	68,5	54	100
Fat																
Chicken Eggs	5	18,5	1	3,7	21	77,8	27	100	1	1,9	2	3,7	51	94,4	54	100
Crackers	12	44,4	3	11,1	12	44,4	27	100	16	29,6	8	14,8	30	55,6	54	100
Pentol	9	33,3	11	40,7	7	25,9	27	100	9	16,7	45	83,3	0	0	54	100
Chicken Offal	4	14,8	1	3,7	22	81,5	27	100	13	24,1	11	20,4	30	55,6	54	100
Tahu Kocek	8	29,6	12	44,4	7	25,9	27	100	13	24,1	24	44,4	17	31,5	54	100
Fiber																
Long Beans	25	92,6	0	0	2	7,4	27	100	48	88,9	1	1,9	5	9,3	54	100
Spinach	4	14,8	7	25,9	16	59,3	27	100	4	7,4	5	9,3	45	83,3	54	100
Pumpkin	25	92,6	2	7,4	0	0	27	100	50	92,6	1	1,9	3	5,6	54	100
Carrots	8	29,6	7	25,9	12	44,4	27	100	2	3,7	19	35,2	33	61,1	54	100
Banana	8	29,6	7	25,9	12	44,4	27	100	5	9,3	15	27,8	34	63	54	100
Energy																
Packaged Drinks	6	22,2	7	25,9	14	51,9	27	100	4	7,4	22	40,7	28	51,9	54	100
Packaged Food	5	18,5	0	0	22	81,5	27	100	10	18,5	2	3,7	42	77,8	54	100
Cilok	6	22,2	7	25,9	14	51,9	27	100	13	24,1	10	18,5	31	57,4	54	100
Chicken Noodles	7	25,9	4	14,8	16	59,3	27	100	4	7,4	20	37	30	55,6	54	100
Instant Noodles	12	44,4	13	28,1	2	7,4	27	100	9	16,7	36	66,7	9	16,7	54	100

Table 3 shows the frequency of macronutrients and fiber. Carbohydrate food sources consumed by the obese group with frequent frequency were white rice (100%) and

vermicelli (100%). Protein source foods that are often consumed with frequent frequency are tofu (96.3%). Fat food sources that are often consumed are crackers (44.4%). Fiber

food sources with frequent consumption were long beans (92.6%) and bananas (29.6%). The most frequently consumed energy source food was instant noodles (44.4%).

Table 4 shows that the average respondent consumes types of food ingredients grouped by macronutrients and fiber during the last month is in the obese group on average consuming 3 types of energy source food ingredients, 4 types of protein source food ingredients, 5 types of fat source food ingredients, 4 types of carbohydrate source food ingredients, and 9 types of fiber source food ingredients. While in the normal group, the average respondent consumed 4 types of food sources of energy, 4 types of food sources of protein, 6 types of food sources of fat, 4 types of food sources of carbohydrates, and 9 types of food sources of fiber.

Table 4 Average Consumption of Foodstuffs by Source of Macronutrients (Energy, Protein, Fat, Carbohydrate) and Fiber with Incidence of Obesity

Macronutrients and Fiber	Obesity		Normal	
	n	%	n	%
Energy	3 types	75.0	4 types	100.0
Protein	4 types	100.0	4 types	100.0
Fat	5 types	125.0	6 types	150.0
Carbohydrate	4 types	100.0	4 types	100.0
Fiber	9 types	225.0	9 types	225.0

The results of table 5 show that the obese group respondents had light physical activity as much as 77.8%, while in the normal group the majority had moderate activity as much as 57.4%. Table 6 also shows the p value <0.005 from the Chi square statistical test results it can be concluded that there is a relationship between physical activity and the incidence of obesity.

Table 5 Distribution and relationship of Physical Activity with the Incidence of Obesity

Physical Activity Level	Obesity		Normal		p-value
	n	%	n	%	
Heavy	0	0	0	0	
Medium	6	22,2	31	57,4	0,000*
Light	21	77,8	23	42,6	
Total	27	100	54	100	

*there is a significant relationship p value <0.005 from the Chi square statistical test results

DISCUSSION

Characteristics of Respondents

Respondents in this study were adolescents of Nuris Jember High School with a range of 16 to 18 years. The results showed the incidence of obesity was found in all age distributions. At the age of 16 to 18 years, adolescents experience a phase of rapid growth and development. Adolescents also experience lifestyle adjustments, especially those related to eating habits. Factors causing obesity include inappropriate food choices and eating patterns that are influenced by two factors, namely individuals and the environment. Many adolescents consume high-calorie sugary foods and drinks and other fast foods because adolescents lack understanding of the nutritional content

and benefits of the food itself. This is what causes obesity in adolescence (Suha & Rosyada, 2022).

Respondents in the study showed that most of the obese respondents were experienced by women (85.2%) compared to men (14.8%). This is because women store more fat in their bodies when compared to men. Adolescent girls experience puberty where there are hormonal changes that serve to mature the function of organs during puberty. This then causes the body to produce more fat (Putri et al., 2022). This is also in line with research conducted by Nugroho (2020), the incidence of obesity in women is 32.9% higher than that of men at 19.7%.

Another study conducted by Saraswati et al., (2021) showed that women have a 10 times risk of obesity compared to men. In addition, the high incidence of obesity in women is due to differences in physical activity levels and energy intake between men and women. Adolescent girls consume more foods that are high in fat and salt, and lack physical activity. Adolescent girls spend more time in the school canteen sitting and snacking, but adolescent boys exercise and play during recess at school. Naturally, women have more body fat reserves when compared to men (World Obesity Federation, 2023). This is also due to women's slower metabolism than men. The metabolic rate in resting conditions for women is 10% lower than that of men (Lubis et al., 2020).

Consumption Patterns with the Incidence of Obesity in Nuris Jember High School

a. Macronutrient Consumption Patterns (Energy, Protein, Fat, and Carbohydrate) with the Incidence of Obesity

Energy needs according to AKG 2019 for women aged 16-18 years are 2,100 kcal, while for men aged 16-18 years are 2,650 kcal. The results of the study regarding energy intake in the obese group were mostly classified as excessive which was caused by most of the obese group respondents consuming high-energy and high-fat foods. This can be seen from the results of the SQ-FFQ frequency that respondents often consume packaged drinks, snacks, cilok, chicken noodles, and instant noodles. This is also in line with research conducted by Rahman et al. (2021) that adolescents often consume snacks such as fried sausages, chiki, cilok, color, round tofu, meatballs, bakwan, instant noodles, chicken noodles, pilus, biscuits, and sweet drinks such as marimas, cocorio, and tea juice. The average consumption according to the number of types of food sources of energy for the obese group, namely 3 types of food sources of energy. While for the normal group, it is 4 types of energy source foodstuffs.

The protein requirement according to AKG 2019 for women aged 16-18 years is 65 grams, while for men aged 16-18 years is 75 grams. The results of research on protein intake in the obese group are mostly classified as excessive. This can be seen from the results of the SQ-FFQ frequency that respondents often consume tempeh, tofu, skipjack fish, tuna, and squid. This is also in line with research conducted by Saprudin, A., Amalia, I. S., & Ropii, A. (2023), the habit of adolescents consuming protein comes from tofu, tempeh, eggs, and chicken. The average consumption according to the number of types of protein food ingredients for obese and normal groups, namely 4 types of protein source food ingredients.

The need for fat according to AKG 2019 for women aged 16-18 years is 70 grams, while for men aged 16-18 years is 85 grams. The results of research on fat intake in the obese

group are mostly classified as excessive. This can be seen from the results of the SQ-FFQ frequency that respondents often consume crackers, pentol, tofu, chicken offal, and free-range chicken eggs. Where this study did not examine the way the food was processed, it could be that the fat intake would be higher because of the way it was processed by frying with oil. Adolescents who have excessive fat intake on average consume foods that are processed using oil or margarine. Types of foods that are often consumed such as fried foods, fried chicken, and french fries. The average consumption according to the number of types of food sources of fat for the obese group, namely 5 types of food sources of fat. As for the normal group, that is 6 types of food sources of fat. Another study conducted by Sari et al., (2019) also showed low dietary diversity in school-age children to the problem of obesity where there was a relationship between dietary diversity and obesity as seen from the percent body fat.

The carbohydrate requirement according to AKG 2019 for women aged 16-18 years is 300 grams, while for men aged 16-18 years is 400 grams. The results of research on carbohydrate intake in the obese group are mostly classified as excessive. It can be seen from the results of the SQ-FFQ frequency that most respondents often get carbohydrates from rice, vermicelli, corn, potatoes, and taro. In addition, students are allowed to add rice at each meal if they feel it is still lacking. This is also in line with research conducted by Putri, R. N., Nugraheni, S. A., & Pradigdo, S. F. (2022), most respondents obtained carbohydrate intake from rice consumption. The average consumption according to the number of types of carbohydrate food ingredients for obese and normal groups, namely 4 types of carbohydrate source food ingredients.

b. Fiber Consumption Patterns with the Incidence of Obesity

Fiber needs according to AKG 2019 for women aged 16-18 years are 29 grams, while for men aged 16-18 years are 37 grams. The results of the study regarding the fiber intake of all respondents, both the obese group and the normal group were classified as less. The average fiber intake in the obese group was 10.67 grams, while the average fiber intake in the normal group was 6.63 grams. This is due to the lack of intake of fruits and vegetables as food ingredients that are rich in fiber. It can be seen from the results of the SQ-FFQ related to the frequency that from several lists of fruit and vegetable food ingredients, most of the respondents in this study were rarely. Teenagers tend to choose fast food that contains high fat, high calories, and low fiber. This factor causes adolescents to consume fewer fruits and vegetables where fiber content is abundant in fruits and vegetables (Purnamaningsih et al., 2023). Most respondents obtained fiber from vegetables, including long beans, pumpkin, carrots, spinach, and a small amount of fruit, namely bananas. This is also in line with research conducted by Pratiwi, I., Masitha Arsyati, A., & Nasution, A. (2022) that the low intake of fiber in their research was caused by the intake of fruits and vegetables that did not follow the recommendations of the Indonesian Ministry of Health, namely 3-4 servings of vegetables and 2-3 servings of fruit per day, which is equivalent to 30grams of fiber per day. The results of research conducted by Purnamaningsih, et al., (2023) that fiber consumption in adolescents is classified as insufficient, which is 68.2%. This is because teenagers prefer fast food which has a bad impact on health. After all, it contains high fat, high calories, and low fiber. The average

consumption according to the number of types of food ingredients for obese and normal groups, namely 9 types of fiber source food ingredients derived from vegetables and fruits. Research conducted by Sholeha, S., & Rasuna, R. A. P. (2023) shows that low dietary diversity and a high risk of overweight and obesity in school-age children are associated with low dietary diversity from food groups that contain fiber, namely fruits, and vegetables.

Physical Activity with the Incidence of Obesity in Nuris Jember High School

Physical activity in the obese group at Nuris Jember High School was classified as light. Most of the activities at Nuris High School are school activities with a duration of 6 hours/day, Islamic activities such as diniyah learning, studies, and memorizing the Koran with a duration of 3 hours/day, school and diniyah activities are done sitting, free activities after school such as resting, extracurricular activities if participating, and just relaxing or filling free time in the dormitory with friends.

Relationship between Macronutrient Diet (Energy, Protein, Fat, and Carbohydrate) and the Incidence of Obesity

The results in this study showed that in the obese group, the majority had excessive macronutrient intake, both energy, protein, fat, and carbohydrates. Excessive macronutrient intake can cause obesity because in general, obesity occurs due to an imbalance between incoming food intake and outgoing energy (Andita, 2020).

The body converts nutrients to obtain energy. These nutrients are protein, fat, and carbohydrates. One gram of protein and one gram of carbohydrate produces 4 kcal, and one gram of fat produces 9 kcal. Excess energy consumption and lack of physical activity result in excess body weight (Mardiana et al., 2022). Most of the excess energy will be stored as fat and this fat storage is what causes obesity (Zahirah Putri et al., 2023). This is also in line with research conducted by Sartorius et al., (2015) showing that there is a significant relationship between energy intake and the incidence of obesity, and excess energy intake has a 35.65 times greater risk of obesity.

Excessive protein intake triggers obesity because foods that contain a lot of animal protein will contain a lot of fat. Animal protein contains amino acids arginine, histidine, and leucine which can increase insulin secretion and are also related to fat metabolism. Excessive protein intake can also cause amino acids to undergo deamidase or the removal of amino groups from a molecule. This causes the body to release nitrogen, and the remaining carbon bonds will be converted into acetyl CoA which can be synthesized into triglycerides through the process of lipogenesis, and then be stored in the body which causes an increase in fat tissue which ultimately causes obesity (Putri, M. P., Dary, D., & Mangalik, G., 2022; Aulia, et.al., 2022). This also supports research conducted by Khairani, N. (2018) which shows a significant relationship between protein intake and the incidence of obesity.

Obesity can occur due to excessive consumption of fat over a long period. A person may overeat high-fat foods because high-fat foods have a delicious taste and low satiating ability. Macronutrient storage capacity determines energy balance, and fat has unlimited storage capacity. Excess fat intake is not accompanied by increased fat oxidation, so about 96% of fat will be stored in the body (Mardiana et al., 2022). This is in line with research

conducted by Suha et al., (2020) which found that there is a relationship between fat consumption and the incidence of obesity in adolescents. According to the findings of research conducted by Telisa, et al., (2020) adolescents' diets that are high in fat, cholesterol, and fast food, and low in fiber have a 6.5 times greater chance of being obese.

Metabolic mechanisms may change due to excessive carbohydrate consumption. Excess glucose will be converted into glycogen and stored in the muscles and liver in limited amounts. Excess glucose will be converted into pyruvate and glycerol because the body only needs a small amount of glycerol, so pyruvate will be immediately converted into acetyl CoA which does not pass through the Krebs cycle and will be stored in adipose tissue (Nurhasanah et al., 2022). This is also in line with research conducted by Telisa, I., Hartati, Y., & Haripamilu, A. D. (2020) showing that obese adolescents tend to consume simple carbohydrates than adolescents who are not obese.

Fiber intake is a nutrient intake that can play a role in controlling body weight and preventing obesity (Jeser & Santoso, 2021). Some types of water-soluble fiber, namely pectin and hemicellulose in fruit, can retain water and can form thick liquids in the digestive tract. So foods rich in fiber have a longer digestion time in the stomach and provide a longer feeling of satiety, preventing you from consuming more food. Foods that are rich in fiber usually contain low energy, low sugar, and fat levels that prevent obesity (Zahirah Putri et al., 2023). In this study, all respondents in both the obese and normal groups had fiber intake in the deficient category or did not reach the recommended RDA. This is also in line with research conducted by Simanoah, K. H., Muniroh, L., & Rifqi, M. A. (2022). that all respondents had insufficient fiber intake. Despite the limitations in analyzing fiber intake directly, the study still contributes to public health by emphasizing the importance of a balanced diet. It underscores the need for comprehensive nutrition education programs that address overall dietary habits rather than focusing solely on specific nutrients like fiber.

Relationship between Physical Activity and the Incidence of Obesity

The results showed that most obese adolescents had mild physical activity. Physical activity is one of the processes of spending or burning energy. A mild level of physical activity can reduce the process of energy expenditure so that energy will be stored in fat tissue (Wrastiani, 2020). The results of this study are in line with research conducted by Mutia et al. (2022) on the relationship between physical activity and the incidence of obesity in adolescents. The study also showed that there was a significant relationship between physical activity and the incidence of obesity in adolescents.

The results in this study, physical activity at Nuris High School consisted of learning at school carried out six days a week, adolescents spent more time in the dormitory and at school with very light activities, such as learning in class done sitting, boarding school learning done sitting, activities after school students prefer to relax with their friends in the dormitory, chatting, sitting, sleeping, eating, doing schoolwork, but some also choose to take part in extracurricular activities such as scouts and KIR (Youth Scientific Work). This is in line with research conducted by Nurhasanah et al., (2022) that the majority of adolescents do physical activity which is classified as low (97.3%). Generally, while at boarding school, santri have little or no physical activity and 41.5% spend four or more hours per day sitting (Trexler et al., 2014).

Children and vulnerable adolescents aged 5 to 17 years are advised to engage in physical activity at school and outside of school with moderate to vigorous intensity every day for at least 60 minutes. Activities such as cycling, swimming, running, jogging, or others. Obesity can occur due to a lack of physical activity and excessive food consumption. WHO recommends doing more than 60 minutes of physical activity every day to provide health benefits and prevent obesity by controlling body weight. If done at least three times a week, this activity is also beneficial for health. (KPKN, 2019).

CONCLUSIONS AND RECOMMENDATION

Most respondents at Nuris High School were 17 years old in the obesity group and 16 years old in the normal group. Respondents were mostly female in both the obesity group and the normal group. Respondents in the obesity group mostly had more energy intake, more protein intake, more fat intake, and more carbohydrate intake. While in the normal group, the majority had sufficient energy intake, less protein intake, less fat intake, and less or sufficient carbohydrate intake. However, all respondents, both the obese group and the normal group had insufficient fiber consumption. and most of the obese group respondents had light physical activity, while in the normal group, the majority had moderate activity. There is a relationship between macronutrient consumption patterns (energy, protein, fat, and carbohydrates) and physical activity with the incidence of obesity at Nuris Jember High School. As for fiber consumption patterns, the relationship between fiber consumption patterns and the incidence of obesity in Nuris Jember High School cannot be analyzed due to homogeneous results. Despite the limitations in analyzing fiber intake directly, the study still contributes to public health by emphasizing the importance of a balanced diet. It underscores the need for comprehensive nutrition education programs that address overall dietary habits rather than focusing solely on specific nutrients like fiber. We recommend developing dietary guidelines in Islamic boarding schools. Such as developing meal plans that include a variety of fruits, vegetables, and healthy fats; emphasizing the importance of including fiber-rich foods despite homogeneous results.

ACKNOWLEDGEMENT

We are sincerely thankful for the support from Summersari Primary Healthcare providing the data needed and Nuris High School Jember who has allowed our research team to conduct the study there.

DECLARATIONS

Ethics Approval and Consent to Participate

The research has carried out research ethics which was carried out in April 2024 at the Health Research Ethics Commission, Faculty of Dentistry, Jember University with No. 2536/UN25.8/KEPK/DL/2024.

Consent for Publication

Not applicable

Availability of Data and Material

The collection of data and material written, produced, and analyzed during the research were obtained from previous research or literature and data is available based on respondent interviews, health service data, and related health centers.

Competing Interest

The authors declare that they have no competing interests.

Funding

This research was not funded by any party.

Authors' Contributions

DN contributed to the development of study design, data collection, data analysis, and manuscript writing. AEN and DIA contributed to the study design, data analysis, and manuscript writing. All authors commented on the manuscript and approved the final version to be published.

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