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MACRONUTRIENT INTAKE AND OBESITY IN ADOLESCENTS: A META-ANALYSIS STUDY

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ABSTRACT

Obesity is a condition with excess body fat due to an imbalance in energy intake consumed more than the physical activity expended. Adolescents who are obese can increase the risk of degenerative diseases. This study aimed to determine the relationship between macronutrients, including carbohydrate, protein, and fat intake, and obesity in adolescents. This study uses a meta-analysis method. Articles were taken from Google Scholar, PubMed, and Science Direct databases. The articles analyzed were articles published from 2000 – 2022, full text; the keywords used for the search were "carbohydrate", "protein", "fat", "obesity, and "adolescents". The articles were collected using PRISMA diagram and analyzed by Review Manager Application 5.4. With the fixed effect model and random effect model. From the results of this study, seven articles were identified. The results of the forest plot show the relationship between carbohydrate intake and obesity in adolescents, p-value < 0.001; OR = 2.58, protein intake with obesity in adolescents obtained p-value = 0.02; OR = 2.92, and fat intake with obesity in adolescents obtained p-value < 0.001; OR = 6.20. The conclusion of this study shows that the variables of carbohydrate, protein, and fat intake have a significant relationship with obesity in adolescents.

Keywords: macronutrients, humans, adolescent, pediatric obesity, carbohydrates, adipose tissue

INTRODUCTION

Obese adolescents experience an extended imbalance between energy intake and output. The consumption of digested energy exceeds that used for metabolism and daily activities. Excess energy intake is stored as fat and fat tissue, resulting in weight gain. (Riswanti, 2016). Being overweight in adolescents is caused by a lack of physical activity and unhealthy eating behaviors such as the consumption of fast food. Teenagers who consume fast food in excess can become obese because fast food has a high nutritional content of fat and high calories (Sani & Handayani, 2021). Adolescent eating patterns are met by macronutrient intake and the amount of intake consumed every day; the expenditure of a small intake is due to a lack of physical activity in adolescents, resulting in obesity (Vionie & Novera, 2020). Adolescents who are obese can increase the risk of degenerative diseases such as heart disease and stroke. Today, the risk of obesity has increased dramatically (Suraya, 2018).

The World Health Organization (WHO) has declared obesity a global epidemic. The prevalence of overweight is increasing very rapidly throughout the world, and developed countries such as Europe, the USA, and Australia have reached dangerous levels (Pajriyah & Sulaeman, 2021). The prevalence of obesity According to the World Health Organization (WHO) 2014, the condition of children aged 5-19 years who were obese reached 39.0%; women were more obese (40.0%) than men (38.0%). Based on the 2018 Basic Health Research Results, the prevalence of obesity in adolescents aged 13-15 years according to (BMI/A) in Indonesia was recorded at 60,020 (4.8%) and adolescents aged 16-18 years at 51,826 (4.0%) (Riskesdas, 2018).

Some research results prove a relationship between macronutrient intake and the incidence of obesity in adolescents. The results of Kurdanti research (2015) found that risk factors for obesity in adolescents are energy intake (OR=4.69), fat (OR=2.34), and carbohydrates (OR=2.64). Anggrainy (2018) research results also prove a relationship between energy intake and adolescent nutritional status. Other studies have shown no correlation between the intake of simple carbohydrates, saturated fat, physical activity levels and nutritional status in adolescents with obesity and obesity. This study is critical because there is still little proves that summarizes the

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relationship between macronutrient intake and obesity in adolescents. Therefore, it is necessary to carry out a meta-analysis to combine two or more research results to obtain new quantitative data.

METHODS

This research design uses a meta-analysis method, a form of quantitative research. The research design used was to analyze the results of previous studies to determine the relationship between macronutrient intake and obesity in adolescents. Articles were obtained from Google Scholar, PubMed, and Science Direct databases. The keywords used in finding articles are (Carbohydrates, protein, fat, obesity, and adolescents). The articles included in this study are articles published from 2000 – 2022. The selected articles discuss the relationship between macronutrient intake and obesity in adolescents, published in Indonesian and English. The research sample is obese adolescents. The data collection process is presented as PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analysis*) diagrams. The study final results were reported using the adjusted Odds Ratio (aOR). Data was processed using Review Manager (RevMan 5.4). The process of searching for articles using a journal search database is shown in Figure 1. The meta-analysis begins with identifying journals, namely searching for journals from the database with specified keywords. The next step is to remove the same articles (removing duplicate articles), followed by a filtration process so that six articles are eligible for meta-analysis to determine the effect of carbohydrate intake on obesity, six articles qualify for meta-analysis to assess the impact of protein intake on obesity, and seven articles are eligible for meta-analysis to determine the effect of fat intake on obesity.

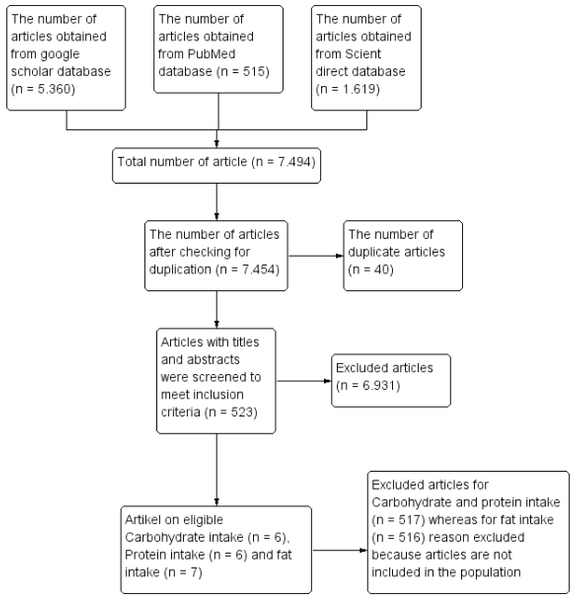


Figure 1. Flow Chart of carbohydrate, protein and fat intake article search process with PRISMA

RESULTS

Figure 2 shows that the variation between studies is heterogeneous. Imelda (2020) showed that excess carbohydrate intake will be at risk of 2 times experiencing obesity. The results of Kartika

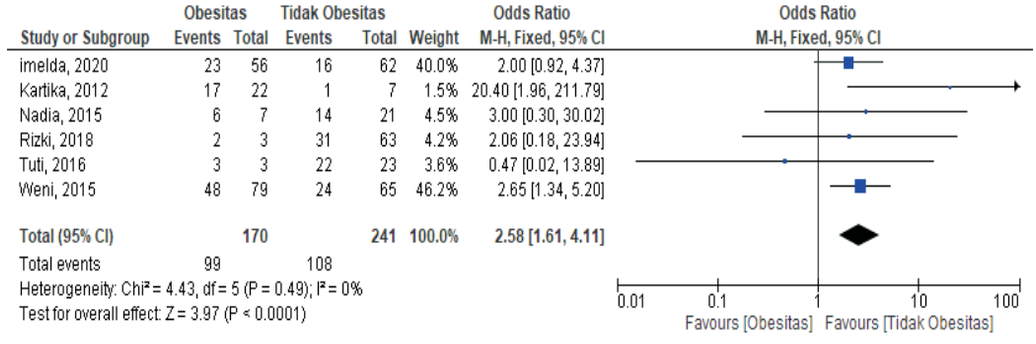
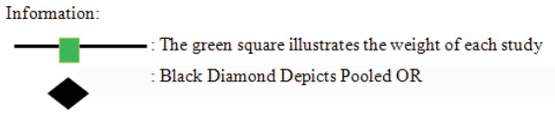


Figure 2. Fores Plot the relationship between carbohydrate intake and obesity in adolescents



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study (2012) the risk of adolescents experiencing obesity is higher (OR=20.4), Nadia (2015) showed that excess carbohydrate intake increases the risk of 3 times obesity, Risk (2018) and Weni (2015) showed the risk of obesity by 2.06 times and 2.65 times when excessive carbohydrate intake, but Tuti (2016) showed no relationship between carbohydrate intake and the incidence of obesity in adolescents. This is evidenced by the p-value in the heterogeneity test, with p = 0.49 and I^2 value 0%, so the fixed effect model is used in this analysis. The forest plot above showed that the pooled odds ratio obtained is 2.58 (95% Cl 1.61 – 4.11), so it can be concluded that adolescents with excessive carbohydrate intake have a 2.58 times greater risk of being obese. There is a significant relationship between carbohydrate intake and obesity in adolescents, evidenced by the p < 0.001.

Figure 3 above shows that the variation between studies is heterogeneous. Imelda (2020) results showed that excess protein intake will be at risk of 3.49 times experiencing obesity. Kartika (2012) (OR=9) and Tuti (2016) (OR=10.59) showed a higher risk of adolescents becoming obese. Nadia (2015) showed that excess carbohydrate intake increased the risk of obesity 2.7 times, Riski (2018) showed the risk of obesity by 4.8 times when excessive carbohydrate intake, but Weni (2015) showed no relationship between protein intake and the incidence of obesity in adolescents. This is evidenced by the p-value in the heterogeneity test, which p = 0.002, and I^2 value 73%, so in this analysis, using the random effect model. The forest plot above shows that the pooled odds ratio obtained is 2.92 (95% Cl 1.15 – 7.46), so it can be concluded that excessive protein intake has a 2.92 times greater risk of obesity in adolescents. There is a significant relationship between protein intake and obesity; this is evidenced by the p = 0.02.

Figure 4 above shows that the variation between studies is heterogeneous. Imelda (2020) results showed that excess fat intake will be at risk of 6.57 times experiencing obesity. Tuti (2016) (OR=23,9), Kartika (2012) (OR=33,75), and Putu (2017) (OR=50.09) showed a higher risk of adolescents becoming obese. Nadia (2015) showed that excess fat intake increased the risk of obesity by 2.46 times, Weni (2015) showed the risk of obesity by 2.34 times with excessive fat intake,

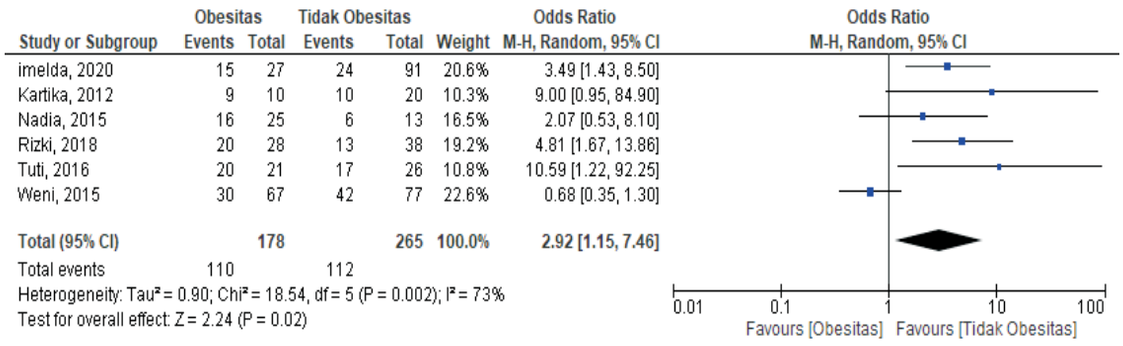

Figure 3. Forest Plot, the relationship of protein intake with obesity in adolescents

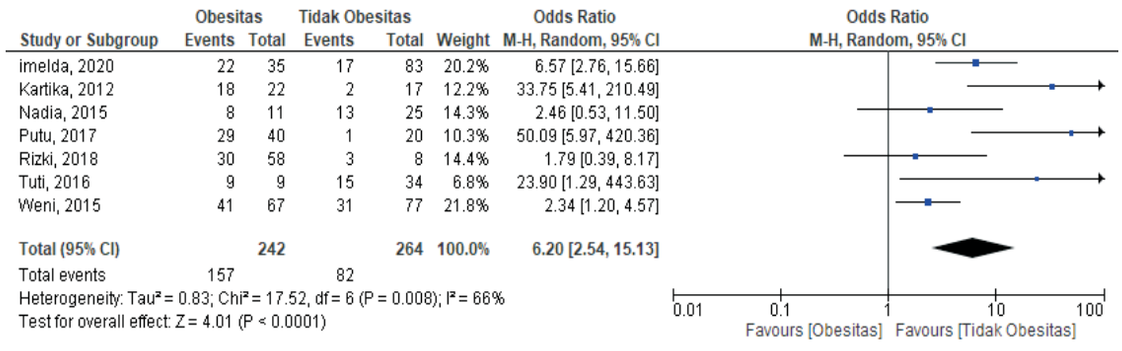

Figure 4. Forest Plot Relationship between fat intake and obesity in adolescents

but Rizki (2018) study showed no relationship between fat intake and the incidence of obesity in adolescents. This is evidenced by the p-value in the Heterogeneity test, which is p = 0.008, and the I^2 value 66%, so the random effect model is used in this analysis. The forest plot above shows that the pooled odds ratio obtained is 6.20 (95% Cl 2.54 – 15.13), so it can be concluded that excessive fat intake has a 6.20 times greater risk of obesity in adolescents. There is a significant relationship between fat intake and obesity; this is evidenced by the value of p = 0.0001.

Figure 5a below shows a funnel plot of the relationship between carbohydrate intake and obesity in adolescents. The left plot has a standard error between 0.4 - 1.75, while the right plot has a standard error of 0.3 - 1.25. Figure 3 shows an asymmetric distribution of research, where the distribution of research is not balanced between the left and right of the center line boundary. Figure 5b shows a funnel plot of the relationship between protein intake and obesity in adolescents. The left plot has a standard error between 0.4 - 0.8, while the right plot has a standard error of 0.5 - 1.25. Figure 3 shows an asymmetric distribution of research, where the distribution of research is not balanced between the left and right of the center line boundary. Figure 5c above shows a funnel plot of the relationship between fat intake and obesity in adolescents. The left plot has a standard error of 0.2 - 0.7, while the right plot has a standard error of 0.5 - 1.5. Figure 5 shows an asymmetric distribution of research, where the distribution of research is not balanced between the left and right of the center line boundary. Based on the Funnel Plot image, it can be concluded that there is a publication bias.

DISCUSSION

Based on a review of 7 articles, the prevalence of obesity problems was 47.58%. The causes of obesity in adolescents are multifactorial, including adolescents who have excessive energy intake, fat intake, protein, and carbohydrate intake. Another factor that can cause obesity is the frequent Consumption of Fast food. The fast-food menu is high in calories, salt, and fat. Fast food consumption can cause various diseases, including obesity (Mulyani et al., 2020). The primary cause of obesity is an energy imbalance between energy intake and energy expenditure over a long period. Excess energy intake is obtained from lack of physical activity, consumption of high-energy foods and snacks such as fast food, and psychosocial influences (Kartolo & Santoso, 2022).

In the seven articles reviewed, it was found that obese adolescents had a percentage of carbohydrate intake of more than 64.26%, protein intake of 62.25%, and fat intake greater than 66.97%. Carbohydrates are the primary source

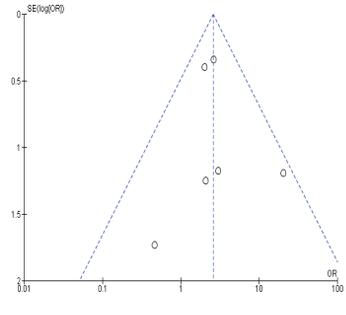

Figure 5a. Funnel plot relationship between carbohydrate intake and obesity in adolescents

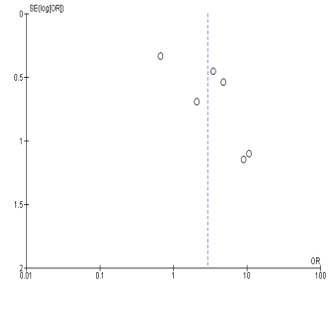

Figure 5b. Funnel Plot the Relationship of Protein Intake with Obesity in Adolescents

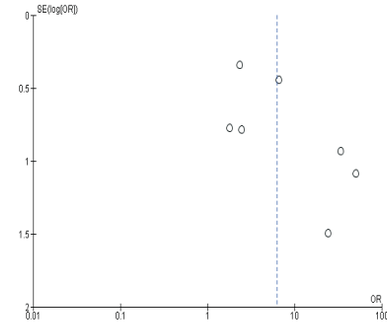

Figure 5c. Funnel Plot Relationship between Fat Intake and Obesity in Adolescents

Information:
SE : Standard Error
❍ : Representing Articles
------- : *Center Line* to see the symmetry of the plot

of macronutrients for the body; if the intake of carbohydrates is excessive, the cells can convert carbohydrates into fat. Carbohydrates that enter through food intake must be balanced with the body needs. An imbalance in carbohydrate intake that enters body can last for a long time, causing nutritional problems, including obesity (Sineke et al., 2019). If adolescents consume protein in amounts that are more than needed, most of the excess protein will be stored in the form of fat. Foods that are high in protein are usually high in fat, which can lead to obesity (Sopiah et al., 2021). Fat intake is the most dominant factor associated with obesity in adolescents. Fat intake has a relationship with obesity; excessive fat intake in the long term can trigger obesity (Telisa et al., 2020).

In this study, carbohydrate intake has a significant relationship with the incidence of obesity in adolescents. Adolescents with excessive carbohydrate intake have a 2.58 times greater risk of being obese. Carbohydrates are nutrients needed by the body in large amounts to produce energy. Adolescents with more carbohydrate intake will be at risk of obesity compared to adolescents who have sufficient carbohydrate intake. Obesity can occur because the carbohydrate intake exceeds the nutritional adequacy rate. Adolescents with more carbohydrate intake will increase insulin secretion, fat storage, and serum triglyceride levels. Excess intake will be stored in muscle or fat. However, if it accumulates for a long time, it will cause obesity. This study is in line with research on adolescents in Kayuuwi village, which states that adolescents with excess carbohydrate intake have a significant relationship with obesity. Carbohydrates are needed for growth, metabolism, utilization of food, and activity. Carbohydrates that enter through food intake must be balanced with body needs. The imbalance in carbohydrate intake that enters the body can last for a long time, causing nutritional problems, including obesity metabolism, food utilization, and activity. Carbohydrates that enter through food intake must be balanced with body needs. The imbalance in carbohydrate intake that enters the body can last for a long time, causing nutritional problems, including obesity metabolism, food utilization, and activity. Carbohydrates that enter through food intake must be balanced with body needs. The imbalance in carbohydrate intake that enters the body can last for a long time, causing nutritional problems, including obesity (Rorimpadei et al., 2020).

Protein intake is a protective factor that can act as an energy source. This is because the intake of fat and carbohydrates is insufficient, so it breaks down protein. Research at Pekunden Elementary School in Semarang said a relationship existed between protein intake and the incidence of obesity ($p = 0.01$). Excess protein intake will break down cell protein into amino acids to be used as energy or stored as fat. In this study, protein intake had 2.92 times greater risk for obesity in adolescents (Rizki et al., 2018). Protein is used as an energy source after undergoing a deaminase process in the liver, namely the hydrolysis of amino acids into keto acids and ammonia (NH_4^+). Then, the amino acids enter the Krebs cycle to be converted into acetyl Co-A, which has been formed and is used to produce fatty acids. Fatty acids play a role in forming adipose cells, forming fat tissue that can increase body weight and become obese (Sopiah et al., 2021). Protein intake in research subjects came from food sources such as vegetable protein and animal protein. Food sources of vegetable protein in adolescents come from nuts, soy products (tofu, tempeh), vegetables, and fruit. One exchange unit of bean (20 gram), tofu (110 gram), and tempeh (50 gram) contain 5 gram of protein. Vegetable and fruit also contain protein but in small amount. One unit of vegetable B (spinach, broccoli, kale, etc.) contain 1 gram of protein, while vegetable C (cassava leave, young jackfruit, etc.) contain 3 gram of protein. The vegetable protein intake consumed by adolescents is mostly coming from fruit. However, because the protein content of fruit is present in small amount, soybean products are the food source of vegetable protein that contribute the most significant to protein content. Subjects' median intake of soy products was 65 gram/day. This amount is still less than the recommended vegetable protein intake, 2-3 units of exchange in one day (Beti, 2015).

Fat intake is the most dominant factor associated with obesity in adolescents. In this study, excessive fat intake had a 6.20 times greater risk for adolescent obesity. Fat intake that exceeds needs in the long term can trigger obesity. Fat is

an essential nutrient as an energy source for every gram of fat that comes from food; the oxidation process in the body will produce nine calories (Sjahmien, 2017). Fat has an unlimited storage capacity, so excess fat intake is followed by increased fat oxidation; about 96% of fat will be stored in the body. In line with Fitriani (2020) said that there was a significant relationship between fat intake and obesity at SMA 86 Jakarta students obtained an OR value of 2.27, which means that respondents have a level of fat intake that is 2.27 times more likely to be obese. Excess fat intake will increase the risk of obesity and will most likely increase the risk of cardiovascular disease (Soetjiningsih, 2004). The advantage of a meta-analysis study is that this method offers a mechanism for estimating the size of the effect in statistical terms (Odds Ratio), and it is significant; combining data from various studies will increase generalization capabilities and statistical power, while the weakness is that there is publication bias.

CONCLUSION

Of the seven articles reviewed, most of the adolescents had an excessive intake of macronutrients, with a prevalence of obesity problems of 47.58%. There is a significant relationship between carbohydrate, protein, and fat intake with obesity in adolescents. It is hoped that it can be used as input and for adolescents to monitor the intake of macronutrients so that no excess intake can lead to obesity in adolescents. Future researchers can conduct similar research by searching for articles in other sources such as DOAJ, Elsevier, Scopus, and Oxford Academic.

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