Amerta Nutrition
e-ISSN: 2580-1163 (Online)
p-ISSN: 2580-9776 (Print)
Hertanto et al. | Amerta Nutrition Vol. 7 Issue 2 (June 2023). 283-294

RESEARCH STUDY
English Version
OPEN ACCESS

Correlation Between Dietary Patterns and Physical Activity Towards Depression Level During Pandemic Among Students of SMAN 1 Manyar Gresik, Indonesia

Hubungan Antara Pola Makan dan Aktivitas Fisik Terhadap Tingkat Depresi di Masa Pandemi Pada Pelajar SMAN 1 Manyar Gresik, Indonesia

Annisa Citra Herrastri Hertanto[1], Ancah Caesarina Novi Marchianti[2]*, Muhammad Hasan[3]

[1]Faculty of Medicine, University of Jember, Jember, Indonesia
[2]Department of Public Health, Faculty of Medicine, University of Jember, Jember, Indonesia
[3]Department of Anatomy, Faculty of Medicine, University of Jember, Jember, Indonesia

ARTICLE INFO

Received: *29-03-2022*
Accepted: *17-01-2023*
Published online: *09-06-2023*

Correspondent:
Ancah Caesarina Novi Marchianti
ancah@unej.ac.id

DOI:
10.20473/amnt.v7i2.2023.283-294

Available online at:
https://e-journal.unair.ac.id/AMNT

Keywords:
Depression, Dietary pattern, Physical activity

ABSTRACT

Background: Unhealthy dietary patterns and low physical activity during a pandemic can be risk factors for depression.
Objectives: This study aimed to analyze the correlation between dietary patterns and physical activities toward depression levels during the pandemic among SMAN 1 Manyar Gresik students.
Methods: This research used observational with a cross-sectional study design at SMAN 1 Manyar Gresik. The sample was 78 students from the 12th grade. The sampling technique used was simple random sampling. The data obtained were then analyzed using the Kendall Correlation test to determine the correlation between dietary patterns and physical activities on the depression level. Each variable was obtained by analyzing the Food Frequency Questionnaire, Food Recall 2x24 hours, International Physical Activity Questionnaire-Short Form, and Modified Beck Depression Inventory-II.
Results: The results showed relationships between diet and depression levels. Diet was assessed from the frequency of the type of food that dominated in the last month and macronutrient intake. There were relationships between the frequency of food consumption that dominated in the last month and the depression level (p=0,003; r=0,319) and between macronutrient intake and depression level.
Conclusions: The results showed the need to increase food consumption from the minimally processed foods group by paying attention to macronutrient intake and performing physical activity in moderate to high-intensity categories according to the recommendations of the adolescent age group to prevent depression.

INTRODUCTION

Depression is still a problem worldwide, with its role as a contributor to the global disease burden. This disease is ranked as the third cause of disability after low back pain and headache disorder[1-2]. Depression contributes to its problems during a pandemic. This condition is evident from a survey conducted by the Indonesian Psychiatric Association where 66% of 1,552 respondents aged 14-71 experienced depression.[3]. The prevalence of depression in various countries also varies, ranging from 15.4% -26.9%[4,5]. Depression not only harms productivity but is also a trigger for suicides, immune dysregulation, and somatic complaints[6-7]. People with depression are in the age range of 15 years to more than 75 years[8]. Depressive conditions are also experienced by grade 12 students at SMAN 1 Manyar Gresik. According to a preliminary study conducted by researchers, 53% of grade 12 students at SMAN 1 Manyar Gresik experience a tendency to be depressed at mild to severe levels.

The pandemic caused the government to issue a policy of imposing restrictions on community activities which had some of the effects of changing learning methods to go online and changing people's lifestyles. One of the affected community groups is high school students, especially grade 12 students at SMAN 1 Manyar Gresik, who, based on preliminary studies, are experiencing problems due to online learning. Modification of the learning model that occurs causes academic stress. Then, during the pandemic, lifestyle changes occurred in the form of decreased physical activity and consumption of unhealthy foods. Types of unhealthy food that can be consumed are ultra-processed, fast, fried, sweet, and low nutrition[9-10]. In this case, the types of unhealthy foods consumed by the study population are ultra-processed. Adopting an unhealthy diet can lead to malnutrition[11,12]. Consumption

How to cite: *Hertanto, A. C. H., Marchianti, A. C. N., & Hasan, M. Correlation Between Dietary Patterns and Physical Activity Towards Depression Level During Pandemic Among Students of SMAN 1 Manyar Gresik, Indonesia: Hubungan Antara Pola Makan dan Aktivitas Fisik Terhadap Tingkat Depresi di Masa Pandemi Pada Pelajar SMAN 1 Manyar Gresik, Indonesia. Amerta Nutrition, 7(2), 283–294.*

of unhealthy food during a pandemic can be caused by stress coping mechanisms caused by limited mobility and problems with food security[12,13-14]. These conditions and the uncertain pandemic can accumulate long-term stressors that cause depressive disorders.

Adopting a healthy lifestyle by consuming healthy foods and undergoing physical activity according to age group recommendations plays a role in preventing depression. This is because healthy food with balanced nutrition is required for productive work and maintaining a healthy body and brain[15-16]. Likewise, regular physical activity can maintain cognitive function and mood[17].

The emergence of the problem of depression during a global pandemic, especially in grade 12 students at SMAN 1 Manyar Gresik, accompanied by low physical activity and unhealthy eating patterns, requires further research to analyze the correlation between these variables. Because a healthy lifestyle plays a role in preventing depression, hopefully, this research can help provide suggestions for maintaining diet and physical activity during the ongoing pandemic to prevent depression.

METHOD

Research Design and Research Subjects

This research uses observational analytic research with a cross-sectional study design and has received permission from the Ethics Commission of the Faculty of Medicine, University of Jember (No. 1564/H25.1.11/KE/2021). The research was conducted in December 2021 at SMAN 1 Manyar Gresik. The population of this study was all 12th-grade students at SMAN 1 Manyar Gresik. The research sample comprised 78 respondents selected based on inclusion and exclusion criteria and obtained through simple random sampling.

Data Collection and Measurement

The research data were obtained from primary data sources in the form of 4 types of questionnaires in the form of a Google form filled out by each respondent and sent via whats app. The questionnaire consists of the Modified Beck Depression Inventory II[18], Food Frequency Questionnaire[19], Food Recall 2x24 hours[20], and the International Physical Activity Questionnaire Short Form[21], which has been validated. In addition, there is an additional identity questionnaire containing questions regarding age, sex, weight, parental education level, and parental income level. Respondents' ages were classified from 16 years to 18 years. Then, gender was grouped into female and male. Furthermore, body weight is classified in the range of 37 kg to 85 kg. Then, parents' education levels were grouped into elementary, junior high, high school, and D3/bachelor. Then, parents' income was grouped from <IDR1,500,000 to >IDR3,500,000.

Questionnaire*Modification of the Beck Depression Inventory II* is used to analyze the trend of depression levels. Depression is a mental disorder that is generally characterized by loss of interest or pleasure, decreased energy, feelings of guilt or low self-esteem, difficulty sleeping, decreased appetite, feelings of tiredness, and lack of concentration.[22], where the symptoms are classified based on the tendency of the degree of severity. Each point from each answer to the questionnaire is totaled, then the results are classified into no depression/minimum depression (score 0-13), mild depression (score 14-19), moderate depression (score 20-28), and severe depression (score 29). -63)[23].

Food Frequency Questionnaire and Food Recall 2x24 hours are used to assess eating patterns. Diet is a sedentary habit related to food consumption based on the type of food and the frequency of consumption[24]. Types of food ingredients consumed were obtained from preliminary studies and classified according to NOVA WHO based on how they are processed into Minimally Processed Foods, Processed Foods, and Ultra Processed Foods.[25]. Minimally Processed Foods are defined as food processing that does not change the properties of food significantly. Types of foodstuffs in this group consist of staple foods (white rice, potatoes); poultry products (chicken meat, chicken eggs, duck meat, quail eggs); beef, seafood products (fish, squid, shrimp, clams, crab); vegetables, fruit, and mineral water. Then, processed foods are made by adding ingredients such as salt, sugar, and oil (processed culinary ingredients) into minimally processed foods using preservative methods or alcoholic fermentation. The types of food ingredients in this group consist of processed soybean products (tempeh and tofu), salted products (salted fish, Pindang fish), and canned products (canned sardines). So, ultra-processed foods are food or beverage products produced from a series of industrial processes in which the properties of the food change and the formation of new products that have added additives. Types of food ingredients in this group are packaged bread (packaged white bread and packaged bread); confectionary products (candy and chocolate); snacks (salty and sweet snacks), packaged noodles (instant noodles and dry noodles/packaged eggs); frozen food made from meat (sausages and nuggets); as well as packaged sweetened drinks (packaged coffee, packaged tea, packaged milk, soda, and isotonic drinks) Types of food ingredients in this group are packaged bread (packaged white bread and packaged bread); confectionery products (candy and chocolate); snacks (salty and sweet snacks), packaged noodles (instant noodles and dry noodles/packaged eggs); frozen food made from meat (sausages and nuggets); as well as packaged sweetened drinks (packaged coffee, packaged tea, packaged milk, soda, and isotonic drinks) Types of food ingredients in this group are packaged bread (packaged white bread and packaged bread); confectionery products (candy and chocolate); snacks (salty and sweet snacks), packaged noodles (instant noodles and dry noodles/packaged eggs); frozen food made from meat (sausages and nuggets); as well as packaged sweetened drinks (packaged coffee, packaged tea, packaged milk, soda, and isotonic drinks)[26]. The Food Frequency Questionnaire asked the frequency of consumption of these types of food in the last month with the following details; (frequency ≥ 3x/day given a score of 50, frequency≤ 2x/day was given a score of 25, frequency of 3-6x/week was given a score of 15, frequency of 1-2x/week was given a score of 10, frequency of 2x/month was given a score of 5, and never consumed was given a score of 0). All foods are summed and compared to determine which ingredients dominate the frequency[27].

How to cite: *Hertanto, A. C. H., Marchianti, A. C. N., & Hasan, M. Correlation Between Dietary Patterns and Physical Activity Towards Depression Level During Pandemic Among Students of SMAN 1 Manyar Gresik, Indonesia: Hubungan Antara Pola Makan dan Aktivitas Fisik Terhadap Tingkat Depresi di Masa Pandemi Pada Pelajar SMAN 1 Manyar Gresik, Indonesia. Amerta Nutrition, 7(2), 283–294.*

Then, diet is also assessed from the intake of macro nutrients as a condition for consuming foods with balanced nutrition. Macro nutrient intake is the average amount of nutrient consumption, including calories, carbohydrates, protein, and fat. The 2x24-hour Food Recall Questionnaire used contains questions about the type of food and its portion consumed for two days (active school days and holidays). Meal portions are converted to a measure of weight (grams), then the intake of each macro nutrient is calculated. Then, the results of the average macro nutrient intake for two days will be compared with the nutritional adequacy rate according to the Nutrition Adequacy Rate Table, which varies depending on the body weight and age of the respondent. Calculation results are converted into percentages, then classified as follows; above nutritional adequacy rate (> 120%), normal (90% - 120%)[26]. Macronutrient analysis using Nutrisurvey software.

International Physical Activity Questionnaire Short Form used to measure physical activity over the last seven days. Physical activity is body movement due to skeletal muscle activity that results in energy expenditure[28]. Interpretation of the questionnaire is classified into low, medium, and high intensity[29]. Determination of the intensity of physical activity using the help of IPAQ Automatic Report Microsoft Excel.

Statistic Analysis

Data analysis was used in the form of univariate analysis and bivariate analysis. The univariate analysis aimed to determine the percentage and frequency of data on the characteristics of the respondents in the form of age, gender, body weight, parents' education level, and parents' income level. Bivariate analysis using Kendall's test correlation with p-value is significant if <0.05. This analysis determined the correlation between dietary pattern variables (viewed from the dominating dietary frequency and macro nutrient intake) and physical activity on depression levels.

RESULTS AND DISCUSSION

Characteristics of Respondents

The characteristics of the respondents were grouped based on age, gender, weight, parental education level, and parental income level. Data on the characteristics of research respondents can be seen in Table 1. Based on the study results, most depressed respondents were 17 years old, female, and had a body weight of 44 kg-50 kg. Then, the father's education level is high school, the mother's education level is D3/graduate, and the parent's income is > IDR3,500,000. Meanwhile, the characteristics of respondents who were not depressed were 17 years old, female, had a body weight in the range of 44 kg-50 kg, father's education level was D3/Bachelor degree, mother's education level was D3/Bachelor degree, and parents' income > IDR3,500,000.

Table 1. Table of characteristics distribution of class XII respondents at SMAN 1 Manyar Gresik in 2021

Characteristics of Respondents	Not depressed		Depression (Mild to Severe)	
	n	%	n	%
Age				
16	2	3%	5	6%
17	19	24%	34	44%
18	6	8%	12	15%
Gender				
Woman	20	26%	37	47%
Man	9	12%	12	15%
Weight				
37 kg- 43 kg	5	6%	7	9%
44 kg- 50 kg	10	13%	12	15%
51 kg- 57 kg	6	8%	3	4%
58 kg- 64 kg	5	6%	10	13%
65 kg- 71 kg	3	4%	7	9%
72 kg- 78 kg	2	3%	4	5%
79 kg- 85 kg	1	1%	3	4%
Father's Education Level				
Elementary School	2	3%	2	3%
Junior High School	2	3%	1	1%
Senior High School	14	18%	25	32%
Vocational Studied/Bachelor degree	15	19%	16	21%
Mother's Education Level				
Elementary School	1	1%	2	3%
Junior High School	1	1%	1	1%
Senior High School	15	19%	17	22%
Vocational Studied/Bachelor degree	16	21%	25	32%
Parents Income				
< IDR1,500,000	5	6%	10	13%
IDR1,500,000 - IDR2,500,000	4	5%	11	14%
IDR 2,500,000 - IDR3,500,000	7	9%	4	5%
> IDR3,500,000.	17	22%	20	26%

How to cite: *Hertanto, A. C. H., Marchianti, A. C. N., & Hasan, M. Correlation Between Dietary Patterns and Physical Activity Towards Depression Level During Pandemic Among Students of SMAN 1 Manyar Gresik, Indonesia: Hubungan Antara Pola Makan dan Aktivitas Fisik Terhadap Tingkat Depresi di Masa Pandemi Pada Pelajar SMAN 1 Manyar Gresik, Indonesia. Amerta Nutrition, 7(2), 283–294.*

It is known that most female respondents were research participants and experienced a tendency to depression. Women are prone to depression because of their stress response. Women who experience menstrual cycles during menstruation tend to experience an increase in the hormone testosterone, which results in the formation of cortisol, which will trigger stress. Then, when exposed to stress, women's HPA Axis system can secrete ACTH more than men, making it easier for cortisol to be produced[30].

Respondents in the age range of 16-18 years experienced depression, with the majority aged 17 years. According to WHO, adolescents are people in the age period of 10-19 years[31]. Adolescence is a phase where there is a transition to adulthood, allowing for emotional instability in overcoming problems. If various stressors appear and cannot be adequately managed, they will trigger depression. Types of stressors vary. Economic problems and self-image can be a contributor to stressors[32].

Economic conditions can be seen from the level of education of parents and the amount of income each month. Respondents who were depressed or not depressed at the educational level of their parents were dominated by high school and D3/Bachelor levels, with incomes that dominated >IDR3,500,000. In addition, several respondents also had parents with elementary and junior high school education levels and incomes below IDR3,500,000.00. Workers with higher education tend to earn higher wages[33]. Groups of people with high incomes can live healthier lives with the ability to access nutritious food, engage in sports and recreation, and have a better place to live. This result contrasts low-income groups of people who face limitations in housing and unhealthy lifestyles[34]. An unhealthy lifestyle can trigger depression. However, it is possible that high-income groups of people can also experience depression due to their inability to deal with stress[35].

Disturbed body image is known to be associated with stressful conditions[36]. A disturbed body image is a form of dissatisfaction about the body triggered by size, shape, function, and limitations changes. Weight triggers a disturbance of self-image[37]. Research respondents have a variety of body weights ranging from 37-85 kg. Certain conditions, such as obesity, can affect self-assessment, manifesting in a negative body image[36].

The Relationship between Diet and Depression Levels

During the pandemic, the dietary patterns found to dominate the eating habits of respondents were minimally processed foods and ultra-processed foods, with the percentage of respondents consuming minimally processed foods at 94% and ultra-processed foods at 6%. As many as 42% of respondents who consumed minimally processed foods were not depressed, 27% had mild depression, 19% had moderate depression, and 6% had severe depression. Meanwhile, 6% of respondents who consumed ultra-processed foods experienced moderate to severe depression. The results of the statistical analysis show that there is a relationship between eating patterns and the level of depression. It is known that respondents who consumed ultra-processed foods had a higher percentage of experiencing depression than those who consumed minimally processed foods[38]. This conclusion is also supported by other studies where ultra-processed foods are associated with the prevalence of depressive symptoms. Conversely, consumption of minimally processed foods is associated with lower depressive symptoms[39]. Several reasons can form the conclusions in this study.

Table 2. Analysis of the Relationship between Diet and Physical Activity on Depression Levels

Variables	Depression Rate								Kendall Correlation
	Not depressed		Mild depression		Moderate depression		Deep depression		
	n	%	n	%	n	%	n	%	
Dietary habit									
Minimally Processed	33	42%	20	27%	15	19%	5	6%	p-value = 0.003
Foods	0	0%	0	0%	3	4%	2	2%	r = 0.319
Ultra Processed Foods									
Calorie Intake									
Above RDA	0	0%	4	5%	5	6%	2	3%	p-value <0.001
Normal	33	42%	0	0%	0	0%	0	0%	r = 0.353
Mild deficit	0	0%	3	4%	1	1%	0	0%	
Moderate deficit	0	0%	4	5%	8	10%	0	0%	
Severe deficit	0	0%	8	11%	4	5%	6	8 %	
Carbohydrate Intake									
Above RDA	0	0%	2	3%	6	8%	2	3%	p-value <0.001
Normal	33	42%	0	0%	0	0%	0	0%	r = 0.363
Mild deficit	0	0%	2	3%	1	1%	0	0%	
Moderate deficit	0	0%	3	4%	6	8%	2	3%	
Severe deficit	0	0%	13	17%	4	5%	4	5%	
Protein Intake									
Above RDA	0	0%	0	0%	0	0%	0	0%	p-value <0.001
Normal	33	42%	2	3%	7	9%	1	1%	r = 0.515
Mild deficit	0	0%	3	4%	3	4%	2	3%	

How to cite: *Hertanto, A. C. H., Marchianti, A. C. N., & Hasan, M. Correlation Between Dietary Patterns and Physical Activity Towards Depression Level During Pandemic Among Students of SMAN 1 Manyar Gresik, Indonesia: Hubungan Antara Pola Makan dan Aktivitas Fisik Terhadap Tingkat Depresi di Masa Pandemi Pada Pelajar SMAN 1 Manyar Gresik, Indonesia. Amerta Nutrition, 7(2), 283–294.*

Variables	Depression Rate								Kendall Correlation
	Not depressed		Mild depression		Moderate depression		Deep depression		
	n	%	n	%	n	%	n	%	
Moderate deficit	0	0 %	7	9%	3	4%	2	3%	
Weight deficit	0	0 %	8	10%	4	5%	3	4%	
Fat Intake									
Above RDA	0	0%	4	5%	4	5%	2	3%	p-value = 0.001
Normal	33	42%	2	3%	1	1%	0	0%	r = 0.327
Mild deficit	0	0%	2	3%	1	1%	0	0%	
Moderate deficit	0	0%	4	5%	6	8%	3	4%	
Weight deficit	0	0%	8	10%	5	6%	3	4%	
Physical Activity									
Low intensity	1	1%	18	23%	17	22%	8	10%	p-value <0.001
Medium intensity	29	37%	2	3%	0	0%	0	0%	r = -0.779
High intensity	3	4%	0	0%	0	0%	0	0%	

*p-value and r were obtained from Kendall's correlation test results. RDA, Recommended Dietary Allowance.

The pandemic has caused people to consume healthy foods from the minimally processed foods group. Succinctly, food materials are *minimally processed foods*Foodstuffs are processed with the minimum possible process without adding food additives and usually reducing the portion of the food without significantly changing its properties. Examples include frozen/fresh fruits and vegetables, fruit juices, whole grains, rice, tubers, frozen or fresh meat, fish, and poultry products[25]. Conversely, some people consume unhealthy food products such as ultra-processed foods as a form of social behavior to store long-lasting food so they can reduce mobility outside the home. Succinctly, food material ultra-processed foods are produced through a series of industrial processes by adding additives and changing the full version of the original food into a new product. Examples include instant noodles, snacks, confectionery products, packaged bread, nuggets, sausages, and packaged drinks[25]. Consumption of ultra-processed foods is related to comfort food, which gives a momentary happy mood when dealing with stress due to pandemic conditions[10,40-41].

The difference in the nutritional content of minimally processed food products can also cause the presence or absence of depressive symptoms. This minimally processed food contains complete nutrition, starting from calories, carbohydrates, protein, fat, vitamins, minerals, and short-chain fatty acids[42-43]. The impact of macro nutrient intake on the level of depression will be explained in the next point. Meanwhile, certain micro nutrients, such as B vitamins, can help synthesize serotonin, dopamine, and GABA neurotransmitters. Then vitamins C, D, and E become antioxidants. Antioxidants are electron-donor compounds that will donate one electron to compounds that are oxidants so that the activity of oxidant compounds is inhibited[44]. Then, the mineral magnesium can help produce BDNF (Brain-Derived Neurotrophic Factor). BDNF is a trophic factor that protects the brain during the inflammatory process[45]. Then, the mineral zinc maintains the nervous system's structure and forms polyunsaturated fatty acids, calcium, and iron, which can synthesize neurotransmitters[46-47]. More specifically, there are also short-chain fatty acids found in vegetables. Short-chain fatty acids are short-chain organic acids made by intestinal microbes through the fermentation of mostly undigested carbohydrates and a small portion of endogenous proteins. The content of short-chain fatty acids can suppress the inflammatory process[48,49]. The neuro-inflammatory process due to the accumulation of cytokines is one of the causes of depression[50]. It is known that most of the respondents who consumed this type of food did not experience depression. On the other hand, in ultra-processed foods, there is a reduction in nutrition and the addition of food additives in almost all food and beverage products[51]. For example, sugar, salt, flavor enhancers, synthetic dyes, and emulsifiers, which according to several previous studies, can trigger symptoms of depression.

Tartrazine and Allura red synthetic dyes can be found in particular food and beverage compositions. These synthetic dyes are suspected of reducing the amount of the neurotransmitter GABA, serotonin, and dopamine, which are mood-balancing neurotransmitters.[52,53]. This condition causes a neurotransmitter imbalance with an increase in excitatory neurotransmitters. Thus, anhedonic behavior and psycho-motor retardation occur[54]. The theory is also proven through experiments on Wistar rats, where administration of tartrazine leads to hyperactivity, antisocial behavior, and anxiety[52,55-56]. Then, synthetic dyes tartrazine and Allura red also play a role in oxidative stress by inhibiting antioxidant performance[56,57-58].

Seasoning consumption of monosodium glutamate in excess means that the excitatory neurotransmitter is increased because glutamate is part of the excitatory neurotransmitter[59,60]. Accumulating glutamate in large quantities causes neuronal death involving DNA damage and triggering apoptosis. This result is due to the glutamate mechanism, which induces mitochondrial calcium absorption and increases mitochondrial respiration to trigger an increase in free radicals. Free radicals along with changes in mitochondrial membrane permeability trigger a process of cell death called excitotoxicity[61]. If excitotoxicity occurs in areas of the brain that play an essential role in dealing with stress, such as the hippocampus, prefrontal cortex, and amygdala, it will inhibit its role in preventing depression.

Emulsifiers are a substance that helps maintain

How to cite: *Hertanto, A. C. H., Marchianti, A. C. N., & Hasan, M. Correlation Between Dietary Patterns and Physical Activity Towards Depression Level During Pandemic Among Students of SMAN 1 Manyar Gresik, Indonesia: Hubungan Antara Pola Makan dan Aktivitas Fisik Terhadap Tingkat Depresi di Masa Pandemi Pada Pelajar SMAN 1 Manyar Gresik, Indonesia. Amerta Nutrition, 7(2), 283–294.*

the stability of oil and water emulsions. This ingredient is known to trigger depressive symptoms. Experiments on rats have shown that emulsifiers can change the mouse microbe to cause low-grade inflammation to obesity[62]. In comparison, research on humans shows that gut bacteria can be affected by emulsifiers to cause inflammation[63].

Consumption of salt and sugar affects depressive symptoms with particular mechanisms. Research conducted on rats by giving high amounts of salt consumption increases T-helper lymphocytes in the small intestine. These cells (T-helper lymphocytes) produce the pro-inflammatory cytokine IL-17, which increases circulation. This condition triggers an autoimmune response in the brain associated with suppressing the anti-inflammatory performance of regulatory T cells[64]. The IL-17 phenotype plays an essential role in the neuro-immune interaction of depression[65]. In addition, there is also an increase in oxidative stress, a decrease in synaptic plasticity, and a decrease in synaptogenesis[64]. Whereas in humans, consumption of high amounts of salt reduces the survival ability of Lactobacillus spp, increasing TH17 cells. This term is classified as an inflammatory process characterized by the release of pro-inflammatory cytokines. Excessive activation of TH17 cells is associated with brain damage[13,66]. High salt intake leads to suppression of the RAAS and increased free radicals. In the brain, free radicals activate sympathetic tone and the local RAAS. Local RAAS will also increase free radicals in the brain[67,68]. Then, intake of high amounts of sugar can trigger hippocampal dysfunction, increase cortisol, and increase the risk of oxidative stress and inflammation[69].

Nutrition obtained by the body is also influenced by the amount consumed at each meal and the way food is processed in the household. Whether or not the portion of food consumed at each meal can affect the portion of nutrition received by the body, where the nutrients obtained impact the symptoms of depression experienced[70,71], not all foodstuffs can be consumed directly. There are several popular food processing in households, such as boiling, steaming, frying, and baking which can reduce the nutritional content of food[72]. This condition could have triggered depressive symptoms in respondents who consumed minimally processed foods.

Steaming is a better cooking method than boiling because it retains water-soluble antioxidants and vitamins[73-74]. Steaming is also the primary cooking method of staple food because it can maintain mineral content. In addition, steaming is an alternative to processing meat with a high cholesterol content because the processing will reduce cholesterol as cholesterol dissolves with water[75]. Meanwhile, boiling can reduce water-soluble vitamins such as vitamin C, and B vitamins and minerals such as phosphorus, calcium, iron, and zinc[76,77]. In addition, the longer boiling time can affect the nutritional content of meat by hydrolyzing protein and reducing the amount of amino acids and fat[72].

Another cooking method is frying. This cooking process can denature proteins, creating a process of gelatinization of starch and evaporation of water which forms a crunchy structure. This process has the advantage of starting to kill bacteria, extending the shelf life of food, and making it delicious. However, frying can affect heat-sensitive nutrients. As a result, there is a decrease in protein, damage to antioxidants, omega three fatty acids, and various fat-soluble vitamins such as vitamins A and E[72,78-79]. In addition, frying can increase the amount of fat and cholesterol[72,75]. Then another cooking method is grilling. The higher the roasting temperature and the longer the duration, the more nutrients will be lost, such as fat, vitamin A, vitamin E, and vitamin C.[72].

Other factors that can influence the number of samples and research design where these two things can affect the accuracy of the data obtained. The sample in this study was relatively small, namely as many as 78 respondents, bearing in mind that there is an imbalance in the number of respondents who consume minimally processed and ultra-processed foods. It is hoped that for further research, samples are taken in larger quantities from a larger population so that they can to provide estimates closer to the sample's characteristics. In addition, the research design used was cross-sectional. The study design studied the correlation between risk factors and disease effects at one point in time, making it difficult to determine cause and effect. In addition, this design also does not describe the course of the disease or prognosis, which needs to be continued with other research designs, such as case control and cohort more accurate in assessing the correlation between risk factors and disease effects[80,81].

The Relationship Between Macronutrient Intake and Depression Levels

During a pandemic, there is a risk of malnutrition. Malnutrition is a deficiency or excess of macro nutrients or micro nutrients[11,82-83].As a result of the PPKM (Implementation of Restrictions on Community Activities) policy issued by the government, food security problems can occur through decreased income, increased food prices, and reduced access[14]. Some of these factors can make it difficult to get nutritious food, thus allowing for a deficit in macro nutrient intake[12,84]. Then, the consumption of ultra-processed foods during a pandemic in large quantities can trigger a condition of excess macro nutrients[85]. This finding follows other research where, during the pandemic, various nutritional problems that adolescents can experience emerged, such as being underweight and obesity[86-87]. Underweight is a nutritional problem in which body weight is too low compared to individuals their age. One of the causes of being underweight is a lack of adequate calorie intake[84]. Studies conducted in Brazil and India show a correlation between household food security problems (the inability to meet the need for sufficient food to live healthily for all family members) and under-nutrition[88-89].

On the other hand, obesity is a condition in which excess fat accumulates so that the body weight exceeds normal. This is caused by an imbalance in caloric intake obtained and expended[90,91]. According to previous research, it is known that teenagers are the highest consumers of ultra-processed foods. These food products are high in calories and, if not balanced with appropriate physical activity, can cause obesity[11,92].

Macro nutrients are the most significant intake of essential nutrients the body needs, including calories, carbohydrates, protein, and fat[93]. Each individual has

How to cite: *Hertanto, A. C. H., Marchianti, A. C. N., & Hasan, M. Correlation Between Dietary Patterns and Physical Activity Towards Depression Level During Pandemic Among Students of SMAN 1 Manyar Gresik, Indonesia: Hubungan Antara Pola Makan dan Aktivitas Fisik Terhadap Tingkat Depresi di Masa Pandemi Pada Pelajar SMAN 1 Manyar Gresik, Indonesia. Amerta Nutrition, 7(2), 283–294.*

different macro nutrient adequacy limits. According to the Guidelines for Regulation of the Minister of Health Number 28 of 2019, the nutritional adequacy rate for each person is determined by gender, age, and body weight. The nutritional adequacy rate for each macro nutrient is classified above the AKG (Nutrition Adequacy Rate), standard, mild, moderate, and severe. The analysis carried out in this study shows a relationship between the intake of calories, carbohydrates, protein, and fat on the level of depression. Compared with some previous research, few studies have discussed this matter. Research conducted in Japan on male workers showed no relationship between calorie, carbohydrate, and fat intake and depression. However, there is a relationship between protein intake and depression, where low protein consumption increases depressive symptoms[94]. Likewise, research conducted in America and Korea shows if there is a relationship between protein intake, which increases the risk of depression compared to those who consume protein within normal limits.[70]. While in this study, it was found that respondents who consumed calories carbohydrates, protein, and fat within normal limits did not experience depression. In contrast, respondents who consumed macro nutrients exceeding the normal AKG criteria or were deficient tended to experience depression. There are several brief explanations of how intake of macro nutrients in compositions that are not ideal (according to the RDA requirements) can cause depression.

Calories are units for calculating energy values, which are derived from the content of carbohydrates, proteins, and fats[95]. Fats are organic compounds of carbon, hydrogen, oxygen, glycerol, and fatty acids. Fatty acids are classified as saturated fatty acids (saturated fatty acids), monounsaturated fatty acids (monounsaturated fatty acids), and polyunsaturated fatty acids (polyunsaturated fatty acids) depending on their chemical structure.[96]. High consumption of calories and fat, in particular, trans fat and saturated fatty acids induce inflammation, promote dysbiosis, and inhibit neurogenesis in the hippocampus[97-98]. Conversely, consuming calories and fat in a deficit category can activate the HPA Axis and increase cortisol[99]. Then, a fat deficit can inhibit the absorption of fat-soluble vitamins such as A, D, E, and K[100]. Vitamins D and E are known to prevent depression[101,102]. Not only that, if omega-3 polyunsaturated fatty acids (Omega 3 PUFA) are consumed in low amounts, it will reduce its function in maintaining the integrity of neuron membranes, reduce its ability to produce anti-inflammatory cytokines, and reduce the amount of serotonin and dopamine.[103,104].

Carbohydrates are the primary energy source for the body consisting of monosaccharides, disaccharides, and polysaccharides[105]. Carbohydrate intake plays a role in influencing mood and behavior. Consumption of carbohydrates can help the entry of tryptophan into the brain. This condition becomes a problem if the consumption of carbohydrates is excessive or deficit. Research conducted on rats shows that excessive consumption of carbohydrates triggers an increase in inflammatory cytokines[106]. Meanwhile, the consumption of carbohydrates in low amounts will lower serotonin levels[107].

Protein comprises the main components of amino acids, which consist of essential and non-essential amino acids. Respondents who consumed protein with a deficit status tended to experience depression compared to respondents who consumed protein at normal levels. This condition is because tryptophan and tyrosine are the two amino acids that manage mood. Brain neurotransmitters are formed from amino acids. Dopamine is made of tyrosine, and serotonin is made from tryptophan[108,109]. Dopamine plays a vital role in the brain, precisely in the mesolimbic dopaminergic pathway. These brain circuits regulate motivation, psychomotor performance, concentration, and feelings of well-being. Then, the neurotransmitter serotonin, located in the dorsal raphe nuclei and median raphe nuclei, plays a role in regulating neuroplasticity, modulating mood, cognition, sleep habits, and controlling appetite.[110,111]. Lack of dopamine and serotonin causes depressive symptoms.

Relationship of Physical Activity to Depression Levels

The physical activities undertaken by the respondents were classified into three based on their intensity. Namely low, moderate, and high levels of physical activity. The analysis that has been done shows that there is a solid relationship between physical activity and depression. Where moderate to high-intensity physical activity is undertaken by respondents who experience mild depression to no depression. Meanwhile, low-intensity physical activity was experienced by respondents with mild to severe depression. This finding is similar to previous research, which stated that children who undergo physical activity at increased intensity reduce the risk of depression[112]. Conversely, individuals who do not suffer from depression will be prone to depression if they undergo low-intensity physical activity[113].

There are factors underlying low physical activity in people who experience depression. Depressed individuals experience fatigue, loss of motivation, and low self-esteem, which triggers a reluctance to do physical activity. In addition, when a person undergoes low physical activity, they can experience an increase in abdominal fat, which is secreted low-grade inflammation of adipose and acts as a chronic stimulus for HPA Axis activation, increasing cortisol secretion[113-114].

Conversely, moderate to high-intensity physical activity is recommended by WHO for the age group of 16 to 18 years[115]. Sport, a type of physical activity of that intensity, contributes well to the brain. This condition is because exercise suppresses pro-inflammatory cytokines and lowers cortisol[116]. There are types of exercise that are effective in reducing depression levels. Among these are aerobic exercise and resistance exercise training[117,118]. Aerobic exercise is a type of physical exercise that increases the load gradually and continuously, utilizing the energy produced by burning with oxygen. Examples include running, walking, cycling, jogging, and others. Aerobic exercise is known to increase hippocampal volume and decrease pro-inflammatory cytokines[117,119]. Resistance exercise training or resistance training is defined as physical activity that causes the muscles to work against a specific resistance or load. Examples

How to cite: *Hertanto, A. C. H., Marchianti, A. C. N., & Hasan, M. Correlation Between Dietary Patterns and Physical Activity Towards Depression Level During Pandemic Among Students of SMAN 1 Manyar Gresik, Indonesia: Hubungan Antara Pola Makan dan Aktivitas Fisik Terhadap Tingkat Depresi di Masa Pandemi Pada Pelajar SMAN 1 Manyar Gresik, Indonesia. Amerta Nutrition, 7(2), 283–294.*

include lifting a barbell, push-ups, sit-ups, and others[120]. Resistance exercise training suppresses pro-inflammatory cytokines and increases anti-inflammatory cytokines, which play a role in neuro-inflammatory processes[121].

CONCLUSIONS

Based on the results and discussion, it can be concluded that there is a relationship between diet, macro nutrient intake, and physical activity on the level of depression, with the most significant correlation strength in the relationship between physical activity and the level of depression, and respondents who consume ultra-processed foods have a higher percentage of experiencing depression. These findings showed the importance of increasing the consumption of minimally processed foods by paying attention to the intake of macro nutrients and carrying out moderate to vigorous intensity physical activity daily.

ACKNOWLEDGMENTS

The author thanks dr. Alif Mardijana, Sp. KJ and dr. Kristianningrum Dian Sofiana, M. Biomed, who provided advice during the research process, and students and teachers at SMAN 1 Manyar Gresik gave permission and supported this research.

Conflict of Interests and Funding Disclosures

All authors have no conflict of interest with any party, and this research was independently funded.

REFERENCES

1. Salleh, M. R. The Burden of Mental Illness : An Emerging Global Disaster. *J. Clin. Heal. Sci.* **3**, 5–12 (2018).
2. James, S. . *et al.* Global, Regional, and National Incidence, Prevalence, and Years Lived with Disability for 354 Diseases and Injuries for 195 Countries and Territories, 1990–2017: A Systematic Analysis for the Global Burden of Disease Study 2017. *Lancet* **392**, 1990–2017 (2018).
3. Ridlo, I. A. Jurnal Psikologi dan Kesehatan Mental Pandemi COVID-19 dan Tantangan Kebijakan Kesehatan Mental di Indonesia. *Insa. J. Psikol. dan Kesehat. Ment.* **5**, 155–164 (2020).
4. Bareeqa, S. B. *et al.* Prevalence of Depression , Anxiety and Stress in China During COVID-19 Pandemic : A Systematic Review with Meta-Analysis. *Int. J. Psychiatry Med.* **56**, 210–227 (2020).
5. Lakhan, R., Agrawal, A. & Sharma, M. Prevalence of Depression, Anxiety, and Stress during COVID-19 Pandemic. *J. Neurosci. Rural Pract.* **11**, 519–525 (2020).
6. Mandasari, L. & Tobing, D. L. Tingkat Depresi dengan Ide Bunuh Diri pada RemaJa. *Indones. J. Heal. Dev.* **2**, (2020).
7. Han, H., Wang, S., Han, C., Lee, S. & Pae, C. The Relationship Between Somatic Symptoms and Depression. *Neuroendocr. Lett* **35**, 463–469 (2014).
8. Ministry of Health of Indonesia. Situasi Kesehatan Jiwa di Indonesia. *www.pusdatin.kemkes.go.id* (2021).
9. Ismail, L. C. *et al.* Dietary Habits and Lifestyle During Coronavirus Pandemic Lockdown: Experience From Lebanon. *Nutrients* **8**, 3314 (2021).
10. Ruíz-Roso, M. B. *et al.* Changes of Physical Activity and Ultra-Processed Food Consumption in Adolescents from Different Countries during Covid-19 Pandemic: An Observational Study. *Nutrients* **12**, (2020).
11. Neri, D. *et al.* Ultraprocessed Food Consumption and Dietary Nutrient Profiles Associated with Obesity : A Multicountry Study of Children and Adolescents. *Obes. Rev.* (2021) doi:10.1111/obr.13387.
12. Alaimo, K., Chilton, M. & Jones, S. J. Food Insecurity, Hunger, and Malnutrition. *Present Knowl. Nutr.* **2**, (2020).
13. Wilck, N. *et al.* Salt-Responsive Gut Commensal Modulates TH 17 Axis And Disease. *Nature* **30**, 585–589 (2017).
14. Ikhsan, M. & Virananda, I. G. S. How Covid-19 Affects Food Security in Indonesia. *LPEM-FEB UI Work. Pap.* **61**, (2021).
15. Oetoro, S., Parengkuan, E. & Parengkuan, J. *Smart Eating: 1000 Jurus Makan Pintar & Hidup Bugar*. (PT Gramedia Pustaka Utama, 2013).
16. Lachance, L. R. & Ramsey, D. Antidepressant Foods: An Evidence-Based Nutrient Profiling System for Depression. *World J. Psychiatry* **8**, 97–104 (2018).
17. Liegro, C. M. Di, Schiera, G., Proia, P. & Liegro, I. Di. Physical Activity and Brain Health. *Genes (Basel).* **10**, (2019).
18. Sorayah. Uji Validitas Konstruk Beck Depression Inventory-II (BDI-II). *J. Pengukuran Psikol. dan Pendidik. Indones.* **4**, 1–13 (2015).
19. Syauqy, A. *et al.* Reproducibility and Validity of a Food Frequency Questionnaire (FFQ) Developed for Middle-Aged and Older Adults in Semarang, Indonesia. *Nutrients* **13**, (2021).
20. Gills, S. M. H., Baker, S. S. & Auld, G. Collection Methods for the 24-Hour Dietary Recall as Used in the Expanded Food and Nutrition Education Program. *J. Nutr. Educ. Behav.* **49**, (2017).
21. Cleland, C., Ferguson, S., Ellis, G. & Hunter, R. F. Validity of the International Physical Activity Questionnaire (IPAQ) for Assessing Moderate-to-Vigorous Physical Activity and Sedentary Behaviour of Older Adults in the United

How to cite: *Hertanto, A. C. H., Marchianti, A. C. N., & Hasan, M. Correlation Between Dietary Patterns and Physical Activity Towards Depression Level During Pandemic Among Students of SMAN 1 Manyar Gresik, Indonesia: Hubungan Antara Pola Makan dan Aktivitas Fisik Terhadap Tingkat Depresi di Masa Pandemi Pada Pelajar SMAN 1 Manyar Gresik, Indonesia. Amerta Nutrition, 7(2), 283–294.*

Kingdom. *BMC Med. Res. Methodol.* **18**, 1–12 (2018).
22. Bernard, J. E. R. Depression: A Review of Its Definition. *MOJ Addict. Med. Ther.* **5**, 7–8 (2018).
23. Gorenstein, C., Lotufo-neto, F., Helena, L. & Wang, Y. P. Validation of the Brazilian Portuguese Version of the Beck Depression Inventory-II in a Community Sample. *Rev Bras Psiquiatr* **34**, 389–394 (2012).
24. Lakaming, N. Status Gizi Anak Sekolah dan Hubungannya dengan Pola Makan di SD Inpres 26 Kabupaten Sorong. (Universitas Papua Sorong, 2019).
25. Monteiro, C. A., Cannon, G., Lawrence, M., Louzada, M. L. da C. & Machado, P. P. Ultra-Processed Foods, Diet Quality, and Health Using the NOVA Classification System. *Rome, FAO* **48**, (2019).
26. Kushartono, C. . & Supariasa. *Survei Konsumsi Gizi*. (Graha Ilmu, 2014).
27. Sirajuddin, Surmita & Trina, A. *Survey Konsumsi Pangan*. (Kementerian Kesehatan Republik Indonesia, 2018).
28. Kristanti. Kondisi Fisik Kurng Gerak dan Instrumen Pengukuran. *Media Litbang Kesehat.* **12**, (2002).
29. IPAQ. Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ) – Short and Long Forms. *Int. Phys. Act. Quest.* 1–15 (2005).
30. Pardamean, E. & Lazuardi, M. J. Hubungan Jenis Kelamin dengan Stres Psikologis pada Siswa-Siswi Kelas XI Jurusan IPA di SMA X Tangerang. *Nurs. Curr.* **7**, (2019).
31. Ministry of Health of Indonesia. *Situasi Kesehatan Reproduksi Remaja*. (2015).
32. Asmika & Handayani, N. The Prevalence of Depression and Description of Phsycosocial Stressor in Adolescent of Senior High Schools in Malang District. *J. Kedokt. Brawijaya* **24**, 15–22 (2008).
33. Julianto, D. & Utari, P. A. Analisa Pengaruh Tingkat Pendidikan Terhadap Pendapatan Individu di Sumatera Barat. *IKRAITH Ekon.* **2**, 122–131 (2019).
34. Woolf, S. H. *et al.* How Are Income and Wealth Linked to Health and Longevity? *Cent. Soc. Heal.* (2015).
35. Richter-Levin, G. & Xu, L. How Could Stress Lead to Major Depressive Disorder? *IBRO Reports* **4**, 38–43 (2018).
36. Putri, R. Hubungan Obesitas dengan Gambaran Citra Tubuh pada Mahasiswa Fakultas Ilmu Pengetahuan Budaya Universitas Indonesia (FIB UI). (Universitas Indonesia, 2012).
37. Nugroho, M. D. & Rizal, A. Citra Tubuh dengan Depresi pada Lansia Wanita. *J. Ilmu Keperawatan Indones.* **7**, 229–234 (2017).
38. Zheng, L., Sun, J., Yu, X. & Zhang, D. Ultra-Processed Food is Positively Associated with Depressive Symptoms Among United States Adults. *Front. Nutr.* **7**, 1–9 (2020).
39. Coletro, H. N. *et al.* Clinical Nutrition ESPEN Ultra-Processed and Fresh Food Consumption and Symptoms of Anxiety and Depression During the Covid-19 Pandemic: COVID Incon fi dentes. *Clin. Nutr. ESPEN* **47**, 206–214 (2022).
40. Hassen, T. Ben, Bilali, H. El & Allahyari, M. S. Impact of COVID-19 on Food Behavior and Consumption in Qatar. *Sustainability* **12**, 1–18 (2020).
41. Izzo, L. *et al.* An Italian Survey on Dietary Habits and Changes during the. *Nutrients* **13**, (2021).
42. Ministry of Health of Indonesia. Peraturan Menteri Kesehatan Republik Indonesia Nomor 41 Tahun 2014 Tentang Pedoman Gizi Seimbang. 1–96 (2014).
43. Quattrini, S., Pampaloni, B. & Brandi, M. L. Natural Mineral Waters: Chemical Characteristics and Health Effects Natural Mineral Waters: Chemical Characteristics. *Clin. Cases Miner. Bone Metab.* **13**, 173–180 (2019).
44. Winarti, S. *Makanan Fungsional*. (Graha Ilmu, 2010).
45. Sahin, C., Dursun, S., Cetin, M. & Aricioglu, F. The Neuroinflammation Perspective of Depression : Reuniting the Outstanding Mechanisms of the Pathophysiology. *Bull. Clin. Psychopharmacol.* **26**, 93–214 (2016).
46. Sasie, S. D. The Role of Micronutrient for Depressed Patients. *J Neuropsychopharmacol Ment. Heal.* **2**, (2017).
47. Othman, R. Ben *et al.* Nutritional Status of Depressive Patients. *J. Diabetes Metab.* **9**, (2018).
48. Wangko, W. S. Aspek Fisiologik Short Chain Fatty Acid (SCFA). *Med. Scope J.* **2**, 26–35 (2020).
49. Filippis, F. De *et al.* High-Level Adherence to a Mediterranean Diet Beneficially Impacts the Gut Microbiota and Associated Metabolome. *Gut microbiota* **65**, 1812–1821 (2016).
50. Carlessi, A. S., Borba, L. A., Zugno, A. I. & Quevedo, J. Gut-Microbiota-Brain Axis in Depression : The role of Neuroinflammation. *Eur J Neurosci.* 1–12 (2019) doi:10.1111/ejn.14631.
51. Moubarac, J.-C. *et al.* Processed and Ultra-processed Food Products: Consumption Trends in Canada from 1938 to 2011. *Can. J. Diet. Pract. Res.* **75**, 15–21 (2014).
52. Mohamed, A. A., Galal, A. A. A. & Elewa, Y. H. A.

How to cite: *Hertanto, A. C. H., Marchianti, A. C. N., & Hasan, M. Correlation Between Dietary Patterns and Physical Activity Towards Depression Level During Pandemic Among Students of SMAN 1 Manyar Gresik, Indonesia: Hubungan Antara Pola Makan dan Aktivitas Fisik Terhadap Tingkat Depresi di Masa Pandemi Pada Pelajar SMAN 1 Manyar Gresik, Indonesia. Amerta Nutrition, 7(2), 283–294.*

Comparative Protective Effects of Royal Jelly and Cod Liver Oil Against Neurotoxic Impact of Tartrazine on Male Rat Pups Brain. *Acta Histochem.* (2015) doi:10.1016/j.acthis.2015.07.002.

53. Uppala, A., SK, M., Swapna, V. N., G, S. L. & P, S. P. International Journal of Recent Scientific. *Int. J. Recent Sci. Res.* **6**, 663–6636 (2015).
54. Haroon, E. & Miller, A. H. Inflammation Effects on Brain Glutamate in Depression: Mechanistic Considerations and Treatment Implications. *Springer Int. Publ. Switz.* (2016) doi:10.1007/7854.
55. Amin, K. A. & Al-shehri, F. S. Toxicological and safety Assessment of Tartrazine as a Synthetic Food Additive on Health Biomarkers: A review. *African J. Biotechnol.* **17**, 139–149 (2018).
56. Bawazir, E. A. Effects of Food Colour Allura Red (No . 129) on Some Neurotransmitter , Antioxidant Functions and Bioelement Contents of Kidney and Brain Tissues in Male Albino Rats. *Life Sci. J.* **13**, (2016).
57. Amin, K. A., Hameid, H. A. & Elsttar, A. H. A. Effect of Food Azo Dyes Tartrazine and Carmoisine on Biochemical Parameters Related to Renal, Hepatic Function and Oxidative Stress Biomarkers in Young Male Rats. *Food Chem. Toxicol.* **48**, 2994–2999 (2010).
58. Gao, Y., Li, C., Yin, H., An, X. & Jin, H. Effect of Food Azo Dye Tartrazine on Learning and Memory Functions in Mice and Rats , and the Possible Mechanisms Involved. *J. Food Sci.* **76**, (2011).
59. Kraal, A. Z., Arvanitis, N. R., Jaeger, A. P. & Ellingrod, V. L. Could Dietary Glutamate Play a Role in Psychiatric Distress? *Neuropsychobiology* **79**, 13–19 (2020).
60. Onaolapo, A. Y. & Onaolapo, O. J. Glutamate and Depression: Reflecting a Deepening Knowledge of the Gut and Brain Effects of a Ubiquitous Molecule. *World J. Psychiatry* **11**, 297–315 (2021).
61. Yang, J.-L., Sykora, P., Wilson, D. M., Mattson, M. P. & Bohr, V. A. Repair to Increase Neuronal Resiliency. *NIH Public Access* **132**, 405–411 (2011).
62. Chassaing, B. *et al.* Colitis and Metabolic Syndrome. *HHS Public Access* **5**, 92–96 (2015).
63. Chassaing, B., Bodt, J. De, Marzorati, M., Wiele, T. Van De & Andrew, T. G. Dietary Emulsifiers Directly Alter Human Microbiota Composition and Gene Expression Ex Vivo Potentiating Intestinal Inflammation. *HHS Public Access* **66**, 1414–1427 (2018).
64. Kendig, M. D. & Morris, M. J. Reviewing the Effects of Dietary Salt on Cognition: Mechanisms and Future Directions. *6 Rev. Artic. Asia Pac J Clin Nutr* **28**, 6–14 (2019).
65. Bli´zniewska-Kowalska, K. *et al.* Is Interleukin 17 (IL-17) Expression A Common Point in the Pathogenesis of Depression and Obesity? *J. Clin. Med.* **9**, (2020).
66. Canale, M. P. *et al.* Gut Dysbiosis and Western Diet in the Pathogenesis of Essential Arterial Hypertension: A Narrative Review. *Nutrients* **13**, (2021).
67. Shimosawa, T. Salt , The Renin – Angiotensin – Aldosterone System and Resistant Hypertension. *Hypertens. Res.* **36**, 657–660 (2013).
68. Cosardereliogluc, C. *et al.* Brain Renin – Angiotensin System at the Intersect of Physical and Cognitive Frailty. *Front. Neurosci.* | **14**, 1–29 (2020).
69. Jacques, A. *et al.* The impact of Sugar Consumption on Stress Driven, Emotional and Addictive Behaviors. *Neurosci. Biobehav. Rev.* **103**, 179–199 (2019).
70. Oh, J., Yun, K., Chae, J. & Kim, T. Association Between Macronutrients Intake and Depression in the United States and South Korea. *Front. Psychiatry* | **11**, 1–9 (2020).
71. Sánchez-villegas, A., Ruíz-canela, M., Gea, A., Lahortiga, F. & Martínez-gonzález, M. A. The Association Between the Mediterranean Lifestyle and Depression. *Clin. Psychol. Sci.* **41085–1093**, (2016).
72. Yong, W., Amin, L. & Dongpo, C. Status and Prospects of Nutritional Cooking. *Food Qual. Saf.* **3**, 137–143 (2019).
73. Castro, N. T. De *et al.* Influence of Cooking Method on the Nutritional Quality of Organic and Conventional Brazilian Vegetables : A Study on Sodium, Potassium, and Carotenoids. *Foods* **10**, 1–12 (2021).
74. Xu, F. *et al.* Domestic Cooking Methods Affect the Nutritional Quality of Red Cabbage. *FOOD Chem.* **161**, 162–167 (2014).
75. Nguju, A. L., Kale, P. R. & Sabtu, B. Pengaruh Cara Memasak yang Berbeda Terhadap Kadar Protein, Lemak, Kolesterol dan Rasa Daging Sapi Bali. *J. Nukl. Peternak.* **5**, 17–23 (2018).
76. Yuan, G., Sun, B., Yuan, J. & WanG, Q. Effects of Different Cooking Methods on Health-Promoting Compounds of Broccoli*. *J. Zhejiang Univ. Sci. B* **10**, 580–588 (2009).
77. Igwemmar, N. C., Kolawole, S. A. & Imran, I. A. Effect of Heating on Vitamin C Content of Some Selected Vegetables. *Int. J. Sci. Technol. Res.* **2**, 209–212 (2013).

How to cite: *Hertanto, A. C. H., Marchianti, A. C. N., & Hasan, M. Correlation Between Dietary Patterns and Physical Activity Towards Depression Level During Pandemic Among Students of SMAN 1 Manyar Gresik, Indonesia: Hubungan Antara Pola Makan dan Aktivitas Fisik Terhadap Tingkat Depresi di Masa Pandemi Pada Pelajar SMAN 1 Manyar Gresik, Indonesia. Amerta Nutrition, 7(2), 283–294.*

78. Zotos, A., Kotaras, A. & Mikras, E. Effect of Baking of Sardine (Sardina Pilchardus) and Frying of Anchovy (Engraulis Encrasicholus) in Olive and Sunflower Oil on Their Quality. *Food Sci. Technol. Int.* **19**, 11–23 (2012).
79. Stephen, N. M., R, J. S., G, J. & D, S. Effect of Different Types of Heat Processing on Chemical Changes in Tuna. *J Food Sci Technol* **47**, 174–181 (2010).
80. Nurhayani. Pengaruh Bauran Pemasaran (Marketing Mix) Terhadap Kepuasan Konsumen Melalui Kualitas Pelayanan Perumahan Metro Cilegon / PT. Perdana Gapura PrimA. *J. Sains Manaj.* **3**, 95–112 (2017).
81. Irmawartini & Nurhaedah. *Metodologi Penelitian*. (Kementerian Kesehatan RI, 2017).
82. Lara-Pulido, A. & Guevara-Cruz, M. Malnutrition and Associated Factors in Elderly Hospitalized. *Nutr. Hosp.* **27**, 652–655 (2012).
83. Sari, W. & Septiani, W. Malnutrisi pada Lansia di Kota Pekanbaru. *J. Kesehat. Komunitas* **5**, 44–48 (2019).
84. Uzogara, S. G. Underweight, the Less Discussed Type of Unhealthy Weight and Its Implications: A Review. *Am. J. Food Sci. Nutr. Res.* **3**, 126–142 (2016).
85. Crimarco, A., Landry, M. J. & Gardner, C. D. Ultra - processed Foods , Weight Gain , and Co - morbidity Risk. *Curr. Obes. Rep.* (2021) doi:10.1007/s13679-021-00460-y.
86. Christian, P. & Smith, R. Adolescent Undernutrition: Global Burden , Physiology , and Nutritional Risks. *Glob. Adolesc. Nutr.* **72**, 316–328 (2018).
87. Nogueira-de-almeida, C. A. *et al.* COVID-19 and Obesity in Childhood and Adolescence: A Clinical Review. *J Pediatr (Rio J)* **96**, 546–558 (2020).
88. Gubert, M. B., Spaniol, A. M., Segall-corrêa, A. M. & Pérez-escamilla, R. Original Article Understanding the Double Burden of Malnutrition in Food Insecure Households in Brazil. *Matern. Child Nutr.* **13**, 1–9 (2017).
89. Coleman-jensen, A., Nord, M., Andrews, M. & Carlson, S. Household Food Security in the United States in 2010. *Food Assist. Nutr. Res. Progr.* (2010).
90. Sandjaja & Sudikno. Prevalensi Gizi Lebih dan Obesitas Penduduk Dewasa di Indonesia. *Gizi Indon* **31**, 1–7 (2005).
91. Septiyanti & Seniawati. Obesitas dan Obesitas Sentral pada Masyarakat Usia Dewasa di Daerah Perkotaan Indonesia. *J. Ilm. Kesehat.* **2**, 118–127 (2020).
92. Cox, C. E. Role of Physical Activity for Weight Loss and Weight Maintenance. *spectrum.diabetesjournals.org* **30**, 157–160 (2017).
93. Mahfira, F. Hubungan Asupan Makronutrien dengan Kadar Malondialdehio Plasma pada Laki-Laki di Kota Padang. (Universitas Andalas, 2019).
94. Nanri, A. *et al.* Macronutrient Intake and Depressive Symptoms Among Japanese Male Workers: The Furukawa Nutrition and Health Study. *Psychiatry Res.* **220**, 263–268 (2014).
95. Chairinniza, K. *100 Questions and Answer: Kolestrol*. (Graha Ilmu, 2010).
96. Bhat, F. Classification , Functional Properties and Health Related Issues Associated with Consumption of Fats: A Review. *Ijppr.Human* **16**, 200–207 (2019).
97. Alcock, J. Fatty Acids From Diet and Microbiota Regulate Energy Metabolism. *F1000Research* **4**, (2015).
98. Marx, W. *et al.* Diet and Depression: Exploring the Biological Mechanisms of Action Diet and Depression : Exploring The Biological Mechanisms Of Action. *Mol. Psychiatry* **26**, 134–150 (2020).
99. Nakamura, Y., Walker, B. R. & Ikuta, T. Systematic Review and Meta-Analysis Reveals Acutely Elevated Plasma Cortisol Following Fasting But Not Less Severe Calorie Restriction. *Stress Int. J. Biol. Stress ISSN* **19**, 151–157 (2016).
100. Ravisankar, P. *et al.* The Comprehensive Review on Fat Soluble Vitamins. *IOSR J. Pharm.* **5**, 12–28 (2015).
101. Głabska, D. *et al.* Vitamin D Supplementation and Mental Health in Multiple Sclerosis Patients : A Systematic Review. *Nutrients* **13**, 1–14 (2021).
102. Manosso, L. M., Camargo, A., Dafre, A. L. & S, A. L. Vitamin E for the Management of Major Depressive Disorder: Possible Role of the Anti-Inflammatory and Antioxidant Systems. *Nutr. Neurosci.* 1–15 (2020) doi:10.1080/1028415X.2020.1853417.
103. Godos, J. *et al.* Diet and Mental Health: Review of the Recent Updates on Molecular Mechanisms. *Antioxidants* **9**, 1–13 (2020).
104. Grosso, G. *et al.* Omega-3 Fatty Acids and Depression : Scientific Evidence and Biological Mechanisms. *Oxid. Med. Cell. Longev.* (2014).
105. Fitri, A. S., Arinda, Y. & Fitriana, N. Analisis Senyawa Kimia pada Karbohidrat Analysis of Chemical Compounds on Carbohydrates. *Sainteks* **17**, 45–52 (2020).
106. Kagal, U. A. & Hogade, A. P. Effect of High Carbohydrate Diet on Complete Freund ' s Adjuvant Induced Inflammation in Rats. *Biomed. Pharmacol. J.* **12**, 1457–1462 (2019).

How to cite: *Hertanto, A. C. H., Marchianti, A. C. N., & Hasan, M. Correlation Between Dietary Patterns and Physical Activity Towards Depression Level During Pandemic Among Students of SMAN 1 Manyar Gresik, Indonesia: Hubungan Antara Pola Makan dan Aktivitas Fisik Terhadap Tingkat Depresi di Masa Pandemi Pada Pelajar SMAN 1 Manyar Gresik, Indonesia. Amerta Nutrition, 7(2), 283–294.*

107. Ebrahimpour-koujan, S., Keshteli, A. H., Afshar, H. & Esmaillzadeh, A. Adherence to Low Carbohydrate Diet and Prevalence of Psychological Disorders in Adults. *Nutr. J.* **18**, 1–9 (2019).
108. Ren, Y. *et al.* Molecular Features of Parkinson's Disease in Patient-Derived Midbrain Dopaminergic Neurons. *Mov Disord* **37**, 70–79 (2021).
109. Höglund, E., Øverli, Ø. & Winberg, S. Tryptophan Metabolic Pathways and Brain Serotonergic Activity : A Comparative Review. *Front. Endocrinol. (Lausanne).* **10**, (2019).
110. Pourhamzeh, M. *et al.* The Roles of Serotonin in Neuropsychiatric Disorders. *Cell. Mol. Neurobiol.* (2021) doi:10.1007/s10571-021-01064-9.
111. Jenkins, T. A., Nguyen, J. C. D., Polglaze, K. E. & Bertrand, P. P. Influence of Tryptophan and Serotonin on Mood and Cognition with a Possible Role of the Gut-Brain Axis. *Nutrients* **8**, 1–15 (2016).
112. Kremer, P. *et al.* Physical Activity, Leisure-Time Screen Use and Depression Among Children and Young Adolescents. *J. Sci. Med. Sport* **17**, 183–187 (2013).
113. Schuch, F. B. & Stubbs, B. Physical Activity, Physical Fitness, and Depression. *Oxford Res. Encycl. Psychol.* (2017) doi:10.1093/acrefore/9780190236557.013.201.
114. Paley, C. A. & Johnson, M. I. Abdominal Obesity and Metabolic Syndrome: Exercise As Medicine? *BMC Sports Sci. Med. Rehabil.* **10**, 1–8 (2018).
115. Bull, F. C. *et al.* World Health Organization 2020 Guidelines on Physical Activity and Sedentary Behaviour. *Br J Sport. Med* **54**, 1451–1462 (2020).
116. Kandola, A., Ashdown-franks, G., Hendrikse, J., Sabiston, C. M. & Stubbs, B. Physical Activity and Depression: Towards Understanding the Antidepressant Mechanisms of Physical Activity. *Neurosci. Biobehav. Rev.* **107**, 525–539 (2019).
117. Al-qahtani, A. M., Shaikh, M. A. K. & Ahmed, I. Exercise as a Treatment Modality for Depression: A Narrative Review. *Alexandria J. Med.* **54**, 429–435 (2018).
118. Gordon, B. R. *et al.* Association of Efficacy of Resistance Exercise Training With Depressive Symptoms Meta-analysis and Meta-regression Analysis of Randomized Clinical Trials. *JAMA psychiatry* **75**, 566–576 (2018).
119. Palar, C. M., Wongkar, D. & Ticoalu, S. H. R. Manfaat Latihan Olahraga Aerobik Terhadap Kebugaran Fisik Manusia. *J. e-Biomedik* **3**, (2015).
120. Hongu, N., Wells, M. J., Gallaway, P. J. & Bilgic, P. Resistance Training: Health Benefits and Recommendations. *Univ Arizona Coop Ext* **21**, (2015).
121. El-kader, S. M. A. & Al-shreef, F. M. Inflammatory Cytokines and Immune System Modulation by Aerobic Versus Resisted Exercise Training for Elderly. *Afr. Health Sci.* **18**, 120–131 (2018).

How to cite: *Hertanto, A. C. H., Marchianti, A. C. N., & Hasan, M. Correlation Between Dietary Patterns and Physical Activity Towards Depression Level During Pandemic Among Students of SMAN 1 Manyar Gresik, Indonesia: Hubungan Antara Pola Makan dan Aktivitas Fisik Terhadap Tingkat Depresi di Masa Pandemi Pada Pelajar SMAN 1 Manyar Gresik, Indonesia. Amerta Nutrition, 7(2), 283–294.*